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Editor:
J. O. S. MACDONALD, B.Sc., A.R.I.C., A.M.I.Chem.E.

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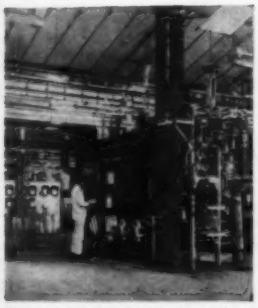

Some of the pilot-plant facilities at the Esso Research Centre at Abingdon showing, in the foreground, a 50-gallon batch reactor. Behind is the main control panel of the pilot steam cracking unit. Flexibility is the keynote in the operation and maintenance of all the equipment.

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Résumés

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ETUDES DE L'ÉLIMINATION PAR LA VAPEUR DU CO_2 DE LA LESSIVE DE SOUDE CAUSTIQUE

par D. Bhargava, G. N. Bhat et E. Weingaertner

Les auteurs ont étudié l'emploi éventuel de colonnes à plateaux à cloches pour éliminer, par la vapeur, le gaz carbonique des lessives de soude caustique. Ils ont déterminé l'influence sur le rendement spécifique des variations de la cadence de l'alimentation en vapeur et en lessive, le rendement par unité de temps et de volume, l'efficacité des plateaux et le coefficient global de transfert massif dans la phase liquide. Ils discutent l'importance des résultats en ce qui concerne l'économie de la production industrielle de CO_2.

B.C.E., 5, 5, 326. U.D.C. No. 622.782: 661.872.2. 096.5.

CALCINATION FLUIDISÉE DES PYRITES

Grâce à un nouveau procédé en deux temps de calcination des pyrites sur lit fluidisé, procédé qui est basé sur la découverte du mécanisme de l'élimination de l'arsénic et du plomb du lit fluide, il est possible de produire un oxyde de fer convenant à la fabrication du fer bien plus économiquement qu'avec les procédés hydrométallurgiques.

B.C.E., 5, 5, 330. U.D.C. No. 66.074.5.

PERTE DE CHARGE, CHARGEMENT ET INONDATION DANS LES TOURS REMPLIES IRRIGUÉES

par H. E. Eduljee

L'auteur passe en revue les publications dans ce domaine et fournit sa propre corrélation améliorée pour divers gaz et liquides. Il illustre son application en calculant la courbe perte de charge/écoulement des gaz pour le système air-eau avec un remplissage de caractéristiques connues. Il donne également une corrélation pour estimer le facteur de remplissage.

B.C.E., 5, 5, 335. U.D.C. No. 66.013: 658.22.003.2.

L'ENTREPRENEUR DE CONSTRUCTION D'USINES DE PRODUITS CHIMIQUES ET LE FABRICANT — 2e PARTIE

par M. Davidmann

L'article examine les relations qui existent entre le fabricant de produits chimiques et l'entrepreneur durant l'exécution d'un contrat. Il étudie, entre autres, la protection des secrets industriels appartenant à l'un ou à l'autre et se demande qui devrait profiter des progrès réalisés durant les travaux. Il discute, également, la pratique actuelle qui consiste à inclure des détails des plans des installations dans des brevets portant essentiellement sur des procédés de fabrication.

B.C.E., 5, 5, 341. U.D.C. No. 66.074.371: 66.096.5.

QUELQUES ASPECTS DU DÉVELOPPEMENT DU PROCÉDÉ FRODINGHAM DE DÉSULFURISATION DES GAZ

par S. A. Gregory

Après avoir étudié les possibilités des lits mobiles, des boîtes d'oxyde conventionnelles utilisées à chaud et de plusieurs autres techniques, on finit par adopter un lit fluide pour désulfuriser le gaz des fours à coke. Il a fallu résoudre un certain nombre de problèmes dans la construction de l'installation expérimentale, en particulier en ce qui concerne la distribution des gaz. Parmi les questions étudiées, l'auteur mentionne l'érosion et la corrosion du matériel, l'absence de contact avec le lit par suite de la formation de bulles d'air, la réduction de la taille des bulles et l'influence de l'épaisseur du lit sur l'efficacité de l'élimination du soufre.

B.C.E., 5, 5, 346. U.D.C. No. 662.766.

LA PRODUCTION DE L'ACÉTYLÈNE PAR OXYDATION PARTIELLE DU MÉTHANE

par C. Cirlogaru

L'auteur examine les trois procédés de fabrication de l'acétylène à partir du gaz naturel et conclut qu'il est préférable d'utiliser le procédé d'oxydation partielle. Il étudie le mécanisme probable de ce procédé et décrit les principales caractéristiques de la réaction. L'auteur énumère un certain nombre de précautions indispensables à la sécurité de l'opération et discute, en outre, diverses méthodes destinées à rendre le procédé automatique et la récupération du produit principal par absorption.

Kurzreferate

B.C.E., 5, 5, 320. U.D.C. No. 66.048.375: 661.97.

STUDIEN ÜBER DEN DAMPFENTZUG VON KOHLENSÄURE AUS SODALÖSUNGEN MITTELS EINER GLOCKENBODENSÄULE

von D. Bhargava, G. N. Bhat und E. Weingaertner

Die Möglichkeit des Einsatzes von Glockenbodensäulen für den Dampfentzug von CO_2 aus Natronlaugen wird untersucht und der Einfluss von Schwankungen in der Dampf- und Sodazufuhr auf die spezifische Ausbeute, die Raum-Zeit-Ausbeute, die Plattenleistung und die Massendurchgangszahl der flüssigen Phase wurden bestimmt. Der Artikel bespricht das Resultat mit Hinsicht auf die Wirtschaftlichkeit der industriellen Erzeugung von CO_2.

B.C.E., 5, 5, 326. U.D.C. No. 622.782: 661.872.2. 096.5.

DAS RÖSTEN VON PYRITEN IN EINER WIRBELBETTANLAGE

Ein neues zweistufiges Röstverfahren für Pyrite, welches auf der Entdeckung des Mechanismus der Erntfernung von Arsen und Blei in der Wirbelschicht beruht, erzeugt ein zur Eisenproduktion geeignetes Eisenoxyd viel wirtschaftlicher als hydrometallurgische Verfahren.

B.C.E., 5, 5, 330. U.D.C. No. 66.074.5.

DRUCKVERLUST, BELASTUNG UND FLUTUNG IN BERIESELTEN PACKUNGSTÜRMEN

von H. E. Eduljee

Nach einer kritischen Übersicht über die diesen Gebiet betreffenden Veröffentlichungen bespricht der Verfasser seine eigene, verbesserte Beziehung, die sich für eine Vielzahl von Gasen und Flüssigkeiten eignet. Die Beziehung wird durch eine Berechnung der Druckabfall-Gasflusskurve für Luft-Wasser mit einer Packung bekannter Kenndaten illustriert. Eine Formel zur Schätzung des Packungsfaktors ist ebenfalls gegeben.

B.C.E., 5, 5, 335. U.D.C. No. 66.013: 658.22.003.2.

DER CHEMIEMANLAGENBAUER UND DER FABRIKANT — TEIL 2

von M. Davidmann

Eine Untersuchung der mitunter bestehenden Beziehungen zwischen dem chemischen Fabrikanten und dem Chemiemanlagenbauer bei der Durchführung eines Projekts. Unter den vielen Punkten ist von grossen Wert besonders die Geheimhaltung der den Partners zugänglichen Daten, da die Parteien aus den erfolgten Verbesserungen ihre Vorteile ziehen wollen, und die Praxis der Anwendung von Konstruktionsdaten der Anlage auf normalerweise als Patente zu betrachtende Verfahren.

B.C.E., 5, 5, 341. U.D.C. No. 66.074.371: 66.096.5.

ASPEKTE DER ENTWICKLUNG DES FRODINGHAM GASENTSCHWEFELUNGSVERFAHRENS

von S. A. Gregory

Nach Erwägung der Möglichkeiten eines beweglichen Bettes, konventioneller heisser Oxydkästen und anderer Verfahren, wurde ein Wirbelschichtverfahren zur Entschwefelung von Koksofengas eingesetzt. Bei der Entwicklung der Versuchsanlage und besonders bei der Gasverteilung musste ein Anzahl von Problemen gelöst werden. Die besonders untersuchten Fragen bezogen sich auf die Erosion und Korrosion der Anlage, Nebenleitung durch Blasen, Mittel zur Verkleinerung der Blasen und der Einfluss der Bettiefe auf die Wirksamkeit der Entschwefelung.

B.C.E., 5, 5, 346. U.D.C. No. 662.766.

AZETYLENERZEUGUNG DURCH TEILWEISE METHANOXYDIERUNG

von C. Cirlogaru

Der Verfasser bespricht die drei Erzeugungsverfahren für Azetylen aus Naturgas und die Vorteile des teilweisen Oxydationsverfahrens. Er erwägt einen möglichen Mechanismus dieses Verfahrens und betont die Hauptzüge der Verbrennungsreaktion. Der Betriebssicherheit wegen müssen verschiedene, von Autor aufgezählte Bedingungen beachtet werden, wobei auch Methoden zur automatischen Verfahrenssteuerung und zur Wiedergewinnung des Hauptprodukts durch Absorption erwähnt werden.

Резюме

B.C.E., 5, 5, 320. U.D.C. No. 66.048.375: 661.97.

ИЗУЧЕНИЕ ВОПРОСА ОБ УДАЛЕНИИ ПАРОВ ДВУОКИСИ УГЛЕРОДА ИЗ РАСТВОРА СОДОВОГО ЩЕЛОКА

Д. Баргава, Г. Н. Бат и Е. Вайнгертнер.

Рассматривается возможность использования тарельчатой колонны с колпаками над тарелками для удаления паров двуокиси углерода из раствора содового щелока. Исследуется влияние изменений в скорости подачи пара и щелока на степень определенной выработки, на выработку на единицу об'ема и времени, на коэффициент полезного действия тарелки и общий жидкофазный массообмен при установленном коэффициенте. Обсуждается значение полученных результатов для экономики производства двуокиси углерода.

B.C.E., 5, 5, 326. U.D.C. No. 622.782: 661.872.2. 096.5.

ФЛУИДАЛЬНОЕ ПРОКАЛИВАНИЕ ПИРИТОВ

Новый, состоящий из двух стадий процесс прокаливания пиритов на флуидальном ложе, основанный на открытии метода удаления мышьяка и свинца из флуидальной тарелки, вырабатывает окись железа подходящую для производства железа. Этот процесс гораздо экономнее гидро-металлургических процессов.

B.C.E., 5, 5, 330. U.D.C. No. 66.074.5.

СОКРАЩЕНИЕ ДАВЛЕНИЯ, НАГРУЗКА, И ЗАХЛЕБЫВАНИЕ В ИРРИГИРОВАННЫХ БАШЕННЫХ НАСАДКАХ

Х. Е. Эдалжи.

Статья дает критический обзор опубликованных трудов по этому вопросу и автор приводит свой собственный, улучшенный метод корреляции подходящей к целому ряду газов и жидкостей. Его применение иллюстрируется исчислением степени сокращения давления в соответствии с кривой потока газа для воздуха — воды при башенной насадке обычного типа. Приводятся также корреляции для определения фактора башенной насадки.

B.C.E., 5, 5, 335. U.D.C. No. 66.013: 658.22.003.2.

СТРОИТЕЛИ ХИМИЧЕСКИХ УСТАНОВОК И ФАБРИКАНТЫ—ЧАСТЬ 2

М. Давидманн.

Изучение отношений существующих иногда во время осуществления различных проектов между химическими фабрикантами и строителями химических установок. В статье, в частности обсуждаются следующие вопросы — охрана информации которой располагает одна из сторон; вопрос о том, кому принадлежат выгоды от усовершенствования полученных в ходе проведения в жизнь данного контракта и обычай включать детали конструкции установки в патенты чисто производственных процессов.

B.C.E., 5, 5, 341. U.D.C. No. 66.074.371: 66.096.5.

РАЗВИТИЕ ПРОЦЕССА «ФРОДИНГЭМ» ПО ИЗВЛЕЧЕНИЮ СЕРЫ ИЗ ГАЗОВ

С. А. Грегори.

После рассмотрения возможностей использования подвижного ложа, обычного типа нагретых коробок окиси и других, был принят процесс флуидального ложа для извлечения серы из газов в коксовальной печи. При конструкции опытной установки пришлось разрешить ряд проблем, в частности распределения газа. Особое внимание было уделено эрозии и окислению оборудования, обходам из за пузырения, способам сокращения об'ема пузырей и влиянию глубины ложа на эффективность удаления серы.

B.C.E., 5, 5, 346. U.D.C. No. 662.766.

ПРОИЗВОДСТВО АЦИТИЛЕНА ПУТЕМ ЧАСТИЧНОГО ОКИСЛЕНИЯ МЕТАНА

С. Сирлогану.

В статье обсуждаются три процесса производства ацитилена из естественного газа и делается вывод, что самым выгодным из них является процесс частичного окисления метана. Рассматриваются возможная аппаратура для такого процесса и описываются главные черты реакции окисления. Для безопасного использования этого процесса необходимо придерживаться ряда приведенных в статье условий. Автор обсуждает также методы автоматического контроля над этим процессом и способ улавливания основного продукта путем абсорбации.

DIGEST OF INDUSTRIAL AND TECHNICAL DEVELOPMENTS

Survey of Fuel and Power

WHAT is the technological approach to the problem of applying efficiently the various energy sources available to us? A broad survey of this field, following a historical introduction, formed the theme of MR. W. K. HUTCHISON'S Presidential Address to the 38th Annual General Meeting of the Institution of Chemical Engineers. His aim was to show that the different forms of energy processing have quite different characteristics, all of which should be exploited on their own merits in the context of a national fuel supply system—an approach complementing perhaps an earlier report on this subject by an earlier President. In his own field of gas production, MR. HUTCHISON noted that if no other factors were involved the choice of raw materials would clearly fall on those with a C/H ratio close to that of town gas. Thus the reforming of methane is an efficient and simple operation and any carbon dioxide produced can be carried in the finished gas as ballast to give it the required specific gravity. Next in preference would be the lighter products of oil refining, and large installations are now at work or under construction for producing town gas from refinery gas or other oil products. Only when these sources are exhausted would it be reasonable to turn to bituminous coal with its much higher C/H ratio. Nevertheless, strategic reasons and the desire to maintain an outlet for coal weigh heavily against technological judgement, and it is significant that even in the United States a considerable research and development effort continues to be applied to the conversion of bituminous coal into liquid fuel and gas.

However, apart from the production aspect the fuel and power industries are increasingly conscious that the cost of distribution of their products tends to absorb some of the economies made possible by large central installations. A valuable tailpiece to the paper was therefore a discussion and table of the comparative costs of transmitting energy. Over 100 miles at 50% load factor it is 1.3d. per therm for gas and 4.1d. for electricity. But liquefied petroleum gases by far beat them both. The comparative figure appears to be 0.32d.

Crystallising Sucrose

WHAT are the factors influencing agglomeration of sucrose crystals? To the extent that laboratory experiments on 100 g. quantities can give guidance, the results of Minoru Kamoda and Takeo Yamane reported in *L'Industria Saccarifera Italiana* (Vol. LIII, No. 1-2, 1960, p. 1) may prove useful. The authors found that stirring the solution up to a speed of about 300 rpm. decreased the number of agglomerates, but a higher rate of stirring had no increased effect. Within the range of temperature studied—up to 50°C—the number of agglomerates increased rapidly with temperature. Two other factors promoting agglomeration were increase in seed density and decrease in crystal size. When the organic impurities, fructose, raffinose, monosodium glutamate and sodium glycollate were added, agglomeration was depressed remarkably as the concentration of added substances increased. On the other hand, glucose had an accelerating effect in lower concentrations but a depressing effect at higher concentrations. A rise in the rates of crystallisation also tended to increase the liability to agglomerate, but if stirring was speeded up this tended to decrease the latter, as noted earlier, although it promoted faster crystallisation.

Designing Vacuum Plant

TO calculate a practical leaky vacuum installation it is necessary to know the leakage coefficient, f. This is defined by the rate of development of pressure in a volume, V, after separating the installation from the pump. The general equation of the curve of pressure against time is $dp = f/V\ .dt$. For a vacuum tight system, $dp/dt = 0$, and hence $f = 0$. Any system for which $f > 0$ is leaky. If there are several leaks, each characterised by its own coefficient $f_1, f_2, \ldots . f_n$ the total leakage coefficient is given by the sum of these. In the case of leaks through gaskets, valves and so on, it is convenient to define a permeability coefficient, a, as the quantity of gas which enters from outside per unit tme per unit length or area of the seal. The relation between a and f is given by $f = \frac{a\ l}{K}$. Here, l is length of seal, for example the circumference of a gasket, and K the specific gravity of the gas divided by the pressure. Choice of pumps then starts with a consideration of the various ways of representing the performance characteristics of vacuum pumps in terms of rate of evacuation at the pump inlet, S. For pipework of conductance C the actual speed of evacuation S is then given by $\frac{l}{S_r} = \frac{l}{S} + \frac{l}{C}$. In a leaky system the pressure in the system cannot fall below a critical value p, directly proportional to the leakage coefficient and inversely to S_r.

This ground is covered in considerable detail by A. ROTH* who gives nomograms and graphs for determining coefficients, pump characteristics and power consumption. ING. ROTH also presents representative ranges of values for a in the case of stuffing boxes for translational or rotational motion; gaskets of leather, cardboard or rubber; evacuated connections; liquid seals and metallic stopcocks or valves. This valuable paper concludes with a composite nomogram relating several properties of the system and thus permitting choice of the most economic combination of conditions.

* *Revista de Chimie*, Vol. 11, No. 2, 1960, p. 78.

Magnetic Concentration of Fines from Blast Furnace Gas

AFTER examining a number of methods of recovering iron from the dusts carried by blast furnace gas, K. NIEMIEC found that electromagnetic separation gave the best results. Normally, direct recycling of this material is difficult. It is exceedingly fine, mostly below 60 microns, and tends to contain a high proportion of silica, low iron, high alkali and zinc. However, the iron component has proved to

be magnetic. The magnetisation is thought to be due to the roasting of the dust whilst it is in the hot gases leaving the furnace and subsequent cooling under reducing conditions, converting the non-magnetic forms of iron compound to the magnetic. ING. DR. NIEMIEC* states that he was able to obtain a concentrate with 68% of iron and only 5% silica using a wet belt separator with four groups of magnets. Fields range from 1000 oersteds for the first to 730 for the fourth. Material to be separated is fed underneath a belt, running under the magnets and dipping into water. Magnetic components stick to the belt until they pass the influence of the field when they fall by gravity into a concentrate tank. The waste falls below the first group of magnets and drains away. Concentrate is washed by water from jets under the belt. The latter is 1m wide and requires 1.5 kW to drive it. Capacity of the separator is about 10-30 t/hr; the magnets require 4.5 kW, washing takes 8-12 m^3/hr of water and the belt runs at 60-100 cm/sec. The speed of the belt determines the water content of the concentrate. A normal figure of 60-80% water in the concentrate is reduced by settling to 25-35% and the solid is finally dried by heating, addition of 10% quicklime, vacuum filtration or just piling. If lime is used, with thorough mixing, suitable aggregates are obtained for direct application. The cohesive strength of the aggregates from the concentrate appears to depend on the particle size distribution in the minus 60 micron range. High proportion of the ultrafines (0-10 microns) results in aggregates which do not crumble into dust easily.

The capital outlay is low and can be recovered in about 3-4 months. One separator can handle material from four blast furnaces.

* *Hutnicke Listy*, Vol. XV, No. 2, 1960, p. 96.

Solving the Riddle of Catalysis

THOUGH every step forward reveals fresh unexplored areas, the introduction of modern physical viewpoints into the chemistry of catalysis has greatly advanced our knowledge. This has involved study of the structure of the solid and its surface, including the question of crystallographic surface orientation and pore structure. Developing these themes in an address at Belfast to the Annual Meetings of the Chemical Society and the Royal Institute of Chemistry, PROFESSOR G. M. SCHWAB referred to the electronic factor. For the formic acid dehydrogenation over Hume-Rothery alloys, the electron concentration of the catalyst has a direct bearing on the catalytic activation energy. This conclusion was corroborated when intermetallic compounds and bi-phasic alloys were examined. In these systems, as in the previous ones, activation energy and resistance or catalysis and conductivity are parallel. But the electric conductivity of these types of alloys, having a conduction zone more than half complete, is linked with the presence of unoccupied electronic levels. These, therefore, must also be connected with the catalytic dehydrogenation and hydrogenation.

This was the first instance of an electronic factor in catalysis, in the sense that in the activation of the rate determining step, electrons have to enter totally or partly into the metal. It soon became clear that not all chemical reactions are of this donor type, like dehydrogenation. Others involving oxygen, like the formation or decomposition of hydrogen peroxide, are of the acceptor type, that is, are favoured by increasing free metal electron concentration. There is, of course, other evidence obtainable on the mechanism of catalysis—from indirect methods like chemisorption or spectroscopy and from direct methods of studying catalysis itself such as using isotopic substitution. But though he reported that the borderline of knowledge has begun to move, PROFESSOR SCHWAB thought we were still a long way from complete solution of the "riddle of catalysis."

Institution Revises its Regulations

Regulations of the Institution of Chemical Engineers for admitting Student, Graduate and Corporate members—first issued in 1954—have been partly revised and re-issued. The new edition can be obtained from the Institution.

Revisions are mainly concerned with defining the qualifications which exempt completely or in part from the examination. In addition, the new brochure incorporates the revised syllabus for the Engineering Drawing Examination, Paper D, which comes into force with the 1960 Examination.

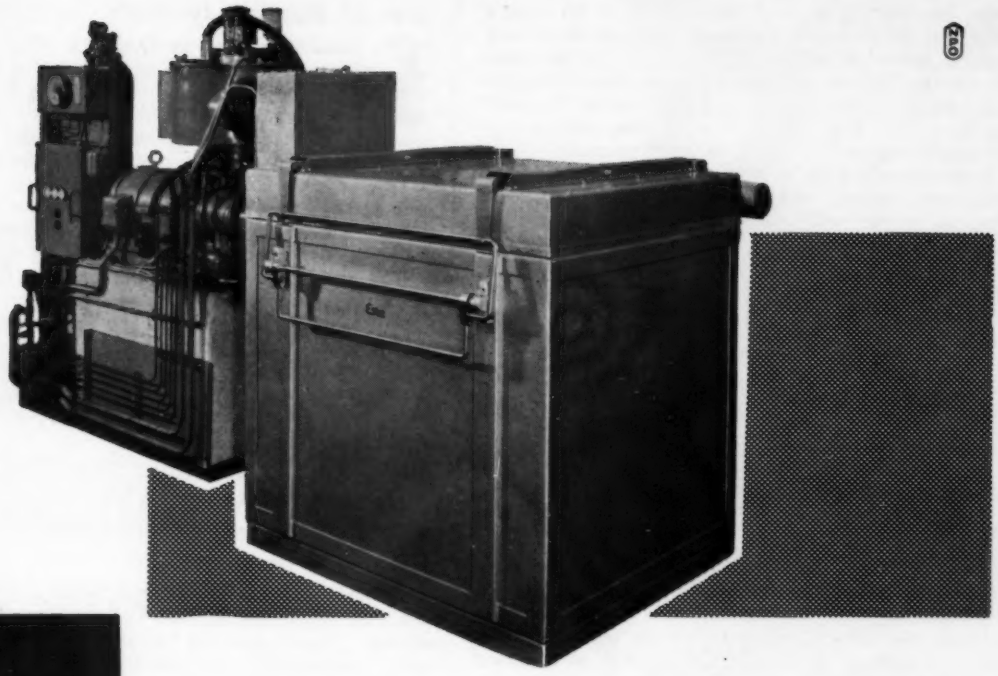
Balancing up Management Studies

BY a strange coincidence we recently found the relatively rare term "imbalance" discussed twice within two weeks. Staunch advocate of the condition was SIR ALEXANDER TODD, F.R.S., replying for the guests at the Oil and Colour Chemists' Association Exhibition Luncheon. There was no such thing as balance in industry. What is more, Sir Alexander considered that without a judicious imbalance, the tremendous advance in the oil and colour industries would have been impossible. Not so the Ministry of Education. For them the condition needs to be corrected. It has arisen in management education which has been too closely associated with economics and commerce to the relative neglect of the social sciences, such as sociology and psychology. Correction of *this* "imbalance" will take place in the course of setting up a new Diploma in Management Studies, an Advisory Council on Management Education, and two new "National Certificates in Business Studies." These changes—agreed with the British Institute of Management and the other bodies concerned—are based largely on the report of a Working Party. Background to this development is the conviction that there must be a major advance in management education. In a circular to local authorities, SIR DAVID ECCLES, Minister of Education, states that this can only be achieved by developing post-graduate courses and research in management comparable with the striking advances in technological subjects made by the Colleges of Advanced Technology and major technical colleges.

Students will normally be required to hold a degree, Diploma in Technology or equivalent professional qualification, and the diploma will be awarded, not before the age of 26, to students who have completed a course of study which may be full-time (up to one year) or part-time (three years), or a mixture of the two. It is hoped that full-time residential courses will be arranged.

Using Radioactivity to Measure Pump Wear

WEAR in multi-stage centrifugal pumps occurs in a number of places. Most important of the sites are the rubbing surfaces of the balance disc, the throttling bush between the balance disc and the high pressure side of the pump, and the inter-stage packing or sealing rings. At the South African National Mechanical Engineering Research Institute they are now using radioactive tracers to examine the wear in 10-stage pumps which deliver 2500 gpm against a head of 3500 ft. In these the throttling bush and the rubbing surfaces of the balance disc—which usually last about 2000 hr—can be replaced relatively easily without dismantling the entire pump. On the other hand, the inter-stage packing



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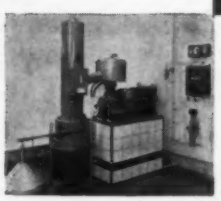

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rings last about 8000 hr, but the entire pump has to be stripped for their replacement. Background to the work is the fact that the gold mining industry in South Africa each day pumps some 120 million gal. of water out of the mines in the country. Settlers are used to remove most of the grit and suspended solids from the mine water before the water enters the pumps. Replacement of worn pump parts contributes significantly to the cost of the whole operation.

The experimental work in hand is aimed mainly at finding a relationship between pump wear and size of particle in suspension in the water, with the ultimate objective of finding the most economical combination of settler size and design and pump maintenance cost.

The first series of experiments was conducted on a laboratory apparatus designed to simulate conditions at the balance disc, where the water flows radially outward between a fixed and a rotating surface. A further series involves a study of wear at the inter-stage rings, where the water flow is axial between fixed and rotating concentric surfaces.

Removing Oil from Effluents

A PROCESS developed for removing fine oil droplets from coking plant wastes may also have useful applications elsewhere. In the first place the oily waste is sprayed on to a bed of coke or coal at the rate of 120 gal. per sq. ft of surface per hr. This is particularly effective with wastes containing more than two hundred milligrammes per litre of oil and where oil is floating on the surface. It removes oil dispersed into droplets of the order of 70 microns or more in diameter. To this basic technique a second stage has been added by the British Coke Research Association. Simple passage through the coke bed is less effective as the droplets become finer and is generally ineffective when the oil is in droplets down to 5 or 10 microns in diameter and for wastes containing 100 milligrammes per litre of oil or less. This material has therefore been treated in a pilot plant using paddles rotating at 180 rev./min. in a cylindrical vessel with about 10% addition of fine coke of 7-14 B.S. mesh to the waste. The suspension was agitated for 5 to 10 min. and a few minutes allowed for settling. Most of the coke sank, carrying the oil with it and the remainder was removed by sand filtration. The method has been successful with benzole-separator water, sulphate-plant and tar-plant effluents and oily water from a tank-farm well containing between 5 and 2000 milligrammes of oil per litre. The final effluent contained below 5 milligrammes per litre in every case.

Adapting the McCabe-Thiele Diagram for Isotope Separation

IN *Chemische Technik*, 1960, Vol. 12, No. 2, DIETZE and PILZ have now published a second paper on adapting the McCabe-Thiele diagram for isotope separation, including the problems arising from the need to use atomic fractions in place of mole fractions and the introduction of corrected magnitudes. This leads on to examination of the reflux ratio for the dual temperature exchange process. There are six variants of chemical exchange methods and they are illustrated in this paper. The exchange can be carried out by means of an open liquid stream and closed circuit gas stream, with removal from the liquid stream in one of two different ways, or removal from the gas stream. Alternatively, there can be an open gas stream and closed circuit liquid stream with removal from the gas stream in one of two different ways, or removal from the liquid stream. After examining the basis of these systems, the authors found it possible to consider the processes and relationships involved in the deuterium exchange in general terms independent of the system being applied. From this they were able to set up a formula for calculating the number of plates for a column assuming a linear operating line and an equilibrium curve. Further development then makes it possible to develop formulae for the numbers of plates for any of the deuterium exchange systems in their six variations. Finally, on the basis of the premises used for derivation of the formula for the number of plates, the authors were able to extend its validity for rectification and extraction.

It may be recalled that last November (*British Chemical Engineering*, Vol. 4, No. 11, p. 572) we also noted a list of the documents made available to the public by the U.S. Atomic Energy Commission on their work on a dual temperature process for producing deuterium.

List of Russian Journals

THE modern technical man's version of keeping up with the Joneses is to be as up-to-date as the next man in scanning the Russian literature. In this sense D.S.I.R. are providing a valuable service for the technically ambitious by their rapid revision and re-issue of their list of Russian Journals held by the Lending Library Unit.* Holdings include periodicals in the original language and translations either in part or whole. The list is equipped with both a subject index based on a broad U.D.C. framework and an index of transliterated abbreviations of titles. In this field developments are taking place at such speed that any list of this kind is bound to be quickly overtaken by events. Since its very recent issue, the Russian Journal of *Physical Chemistry* has also become available in cover-to-cover translation published by the Chemical Society.†

* 20 Chester Terrace, London, N.W.1.

† For those in the Manchester area, a somewhat similar list of titles held by four local libraries has been compiled and published under the direction of Mr. Ardern of the Manchester College of Science and Technology.

Evaporating Neutral Sulphite Spent Liquors

In the pulp and paper industry it is essential to recover and re-use the inorganic chemicals employed in the cooking of wood. Almost all the cyclic recovery processes now in use or under development are based on concentrating by evaporation the spent pulping liquors containing both inorganic and organic constituents then burning the concentrate to generate steam and free the inorganic chemicals for conversion and re-use. The neutral sulphite process employs a mixture of sodium sulphite, carbonate, and bi-carbonate as the cooking chemicals and is used primarily in the high yield pulping of hardwoods.

Heat transfer data on spent pulping liquors in a forced-circulation evaporator have been meagre, but one of the papers in a newly-published collection * helps to fill the gap. Data are presented on over-all heat transfer coefficients, and analysed to yield film coefficients on both the liquor and the steam sides for a semi-commercial (3 ft. O.D.) forced circulation evaporator with external heat-exchanger of two-pass tube and shell design. The main variable was the liquor velocity through the tubes of the heat exchanger. S. T. HAN *et al* found the overall coefficient to range from 496 to 788 Btu/hr sq. ft. °F. The programme of work included a series of continuous steady state runs with neutral sulphite spent liquors, as well as a number of water runs for calibration purposes. The liquor runs were planned to simulate quadruple-effect operation with

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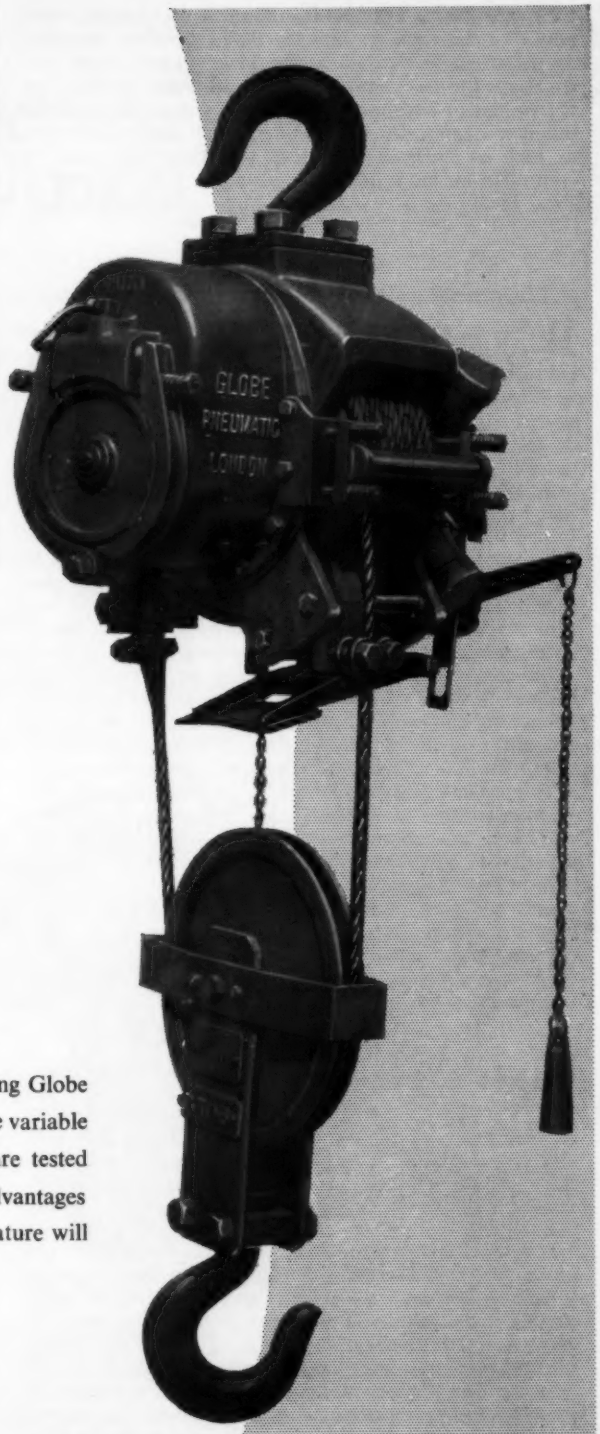

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backward feed. Two points of particular interest were noted by the authors: first the liquor flow was confined to the streamline region at the lower pump speeds and overlapped to the transition zone at the higher speeds. The correlation of heat transfer coefficients therefore required different treatments. Second the overall coefficients were of such an order of magnitude that they were virtually controlled by the inside film resistance.

* Heat Transfer, Chicago, Chemical Engineering Progress Symposium Series, No. 29, Vol. 55, American Institute of Chemical Engineers.

"Thermosensitive Culling"

BASED on the discovery at the Battelle Memorial Institute (Columbus, Ohio) that pure salt crystals transmit infra-red rays of wave lengths varying between 0.3 and 3 microns, while gangue inclusions in impure crystals absorb them, a novel separation process has been developed. Crude rock salt crystals, ranging from 1¼ to ¼ in. in diameter are fed from a hopper on to a vibrating feeder which carries them under a bank of infra-red lamps for about one minute. Then the mixed crystals are fed in a single layer on to a conveyor belt treated with low-molecular-weight styrene resins and remain on it for one second. The heated impure crystals adhere to the belt. When the belt turns over the end roller the pure crystals fall away while the impure ones are carried on to a wire scraper which removes them, dropping them into a reject container.

The commercial variant of this plant, set up by the International Salt Co. of Detroit has a radiant heat panel with 240 industrial infra-red lamps suspended 6 in. above the salt bed, and a separation belt 5 ft wide, 22 ft long, travelling at 960 ft/min. It is said that the technique is applicable to many other products. Higher heat inputs can produce usable temperature changes in sulphides, graphite, cassiterite, wolframite, and fine-grained haematite. This would permit such materials to be separated from many minerals of low heat absorption including heat-transparent types such as cryolite, quartz and calcite. Heat-reflecting types such as kaolin, bauxite and chalky calcite might also be refined.

Papers giving details of the process were presented before the American Institute of Mining, Metallurgical and Petroleum Engineers and are due to be published.

Process Economics

JUDGING by the composition of the papers at a recent highly successful Midlands conference, process economics is a subject with two distinct parts. Do they correspond to strategy and tactics? One of them discusses the question, "which way are we going?"; the other examines detailed questions of process development. Appropriately enough, a representative from one of the giants of the industry was asked to look into the crystal ball and do some long-range forecasting. To open the event—organised by the Midlands Branch of the Institution of Chemical Engineers—Mr. L. S. MUMFORD, Development Controller of I.C.I., set out the sections of the present-day industry and estimated the growth over the next 10 years of some of the major end products. By 1970 total production of organic chemicals was likely to increase by about 2½ while inorganics would be up 40%. How would these increases be distributed? U.K. production of rayon in 1970 might be 270,000 tons per annum and the truly synthetic fibres 150,000 tons. This would represent a growth rate of 2.1% for rayon and of 12.8% for the truly synthetic fibres. Successive impacts have been made by the rayons, a polyamide, a polyester, followed by two acrylics. Now a great deal of work is being done on polypropylene fibre. In the field of plastics our total output may be around one and a quarter million tons, of which approximately 75% will be thermoplastic types. This means a growth rate of 8.7% compound per annum. The present leaders, polyethylene, polyvinyl chloride and copolymers, polystyrene and polyacrylics, are likely to have the lion's share with polypropylene as successor to polyethylene. Polyformaldehyde is another very interesting material and more will be seen of the polycarbonates. Unsaturated polyesters are also finding many new applications. The growing use of foam plastics seems likely to continue.

Around the same date, total consumption of new rubber may be about 380,000 tons per annum, 50-60% of this being synthetic. Nitrogen for fertilisers should then be about 450,000 tons, representing an annual growth rate of 2.8%. There is an increasing use of more concentrated fertilisers and here urea with 45% N and ammonium nitrate with 35% are of potential value in the production of compound fertilisers with a high nutrient content.

Turning then to one of the most basic chemicals of all, sulphuric acid, MR. MUMFORD noted that for 25 years production has been steadily increasing at the rate of 4.3% compound interest. If this continues, production in 1970 will be about 4 million tons of H_2SO_4.

Finally, facing up to an obvious danger in this story of continued progress, the speaker expressed the view that there was not much likelihood of our running into a shortage of raw materials.

Extending Use of Radiation Demand Specialised Health Training

ECONOMICALLY valuable uses of radioactivity cannot be safely introduced or exploited in any country unless there is some preparation of health safeguards, and unless the public health authorities and personnel have the awareness, competence and preparation to fulfill their responsibilities in both routine and emergency situations. This point was stressed by the Director-General of the World Health Organisation in a recent address to the Royal Society of Health in London.

DR. M. G. CANDAU said that W.H.O.'s primary task in this field was to assist countries in the training of physicians, public health officers, nurses, sanitary engineers, health educators and industrial hygienists in the various aspects of radioactivity, ionising radiation and atomic energy. He therefore recommended a pre-clinical course in physics to cover the nature of radiations and allied subjects. There should also be post graduate teaching.

Beneficent Exploitation . . . . . of Minerals

AN exceptionally rich bed of ore—to use the appropriate simile—was provided for technical prospectors of many kinds of interest by the Fifth Sir Julius Wernher Memorial Lecture of The Institution of Mining and Metallurgy. Delivered by DR. I. W. WARK* it matched up to its wide ranging title "Exploitation of Minerals for Mankind." It even included some sociological sidekicks at those who would exploit mankind for minerals. We would however like to extract only two elements. One was the emphasis on basic research. For example, a colleague of the lecturer, DR. K. L. SUTHERLAND, had made a major contribution to flotation research by bringing to bear on its problems a deep knowledge of physics. Later the same principles of surface chemistry which were thus developed were applied in devising adsorption processes for recovery of metals from solutions, and in hindering

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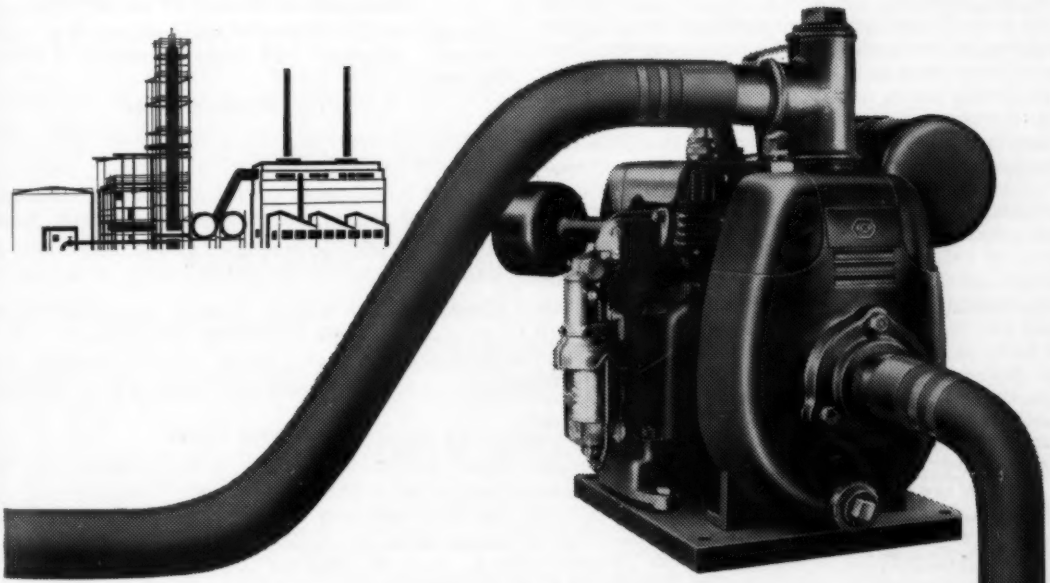

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evaporation from mine reservoirs by applying unimolecular films of compounds similar in constitution to the collectors of the flotation plant. Surface chemistry crops up anew in controlling the separation of minerals by the electrostatic method. It obtrudes in electrowinning of metals where it contributes to the understanding of the phenomenon of overvoltage—a phenomenon so essential to operation of the electrolytic zinc process. Here DR. WARK's general theme was to criticise those who stick too closely to the problem in hand using only an extension of the methods that have been used before.

In process development however there is a complementary problem. It is also essential to note the special features of local conditions or materials. In the C.S.I.R.O. laboratories an investigation of fluidised roasting of copper ores and subsequent electrowinning of copper from the leached calcines was carried to a scale of up to three tons of unroasted concentrates a day. Considerable developments were made in the process but each of four ores investigated had individual characteristics requiring individual treatment, and once again the conviction was confirmed that the testing of ores almost invariably involves research. Too many full-size plants, concluded the lecturer, suffer from insufficient laboratory and pilot-plant preparations. You cannot assume that what works in Germany will suffice in Samoa: you must prove it before you spend your own or your client's money.

* Director of Chemical Research Laboratories, Commonwealth Scientific and Industrial Research Organisation, Australia.

Continuous Culture Processes

IS the fashion again changing in respect of industrial biochemical processes? The wave of interest that surged up to a few years ago had seemed to recede but a recent London symposium on continuous culture of micro-organisms* was successful well beyond the hopes of its organisers. Among the 14 formal papers were both theoretical and practical industrial analyses of continuous culture systems. Production of bakers' yeast, Chlorella cells and the like, or of butanediol by continuous deep fermentation or acetic acid in "vinegar towers," have all, when operated continuously, been described as examples of "continuous culture." So have production of antibiotics and vitamins, transformation of steroids, disposal of industrial wastes and various sewage disposal processes, including trickling filters. DENIS HERBERT of the Microbiological Research Establishment, Porton Down, pointed out, however, that many of these differ from each other as much as they differ from batch processes. He went on to discuss criteria for the classification of continuous culture systems and suggested a primary sub-division into "closed" and "open" systems; only the latter are capable of steady-state operation for indefinite periods. Mathematical analysis of several types of process presented in the paper should make quantitative predictions of their behaviour possible.

* Organised by Society of Chemical Industry Microbiology Group. To be published in *Chemistry and Industry* and in a separate publication.

Engineering Hair Removal

LEATHER-MAKING is not at first glance a very obvious field of study for chemical engineers, yet the research association of that industry* has found it useful to set up a sub-committee entirely devoted to applying this technology. The laboratory's chemical engineering research team under the leadership of DR. F. E. HUMPHREYS correspondingly has a number of achievements to its credit. They include a countercurrent drying tunnel, now installed and in operation in a number of tanneries. The tunnel is designed on the "straight-through" principle and effects considerable economy in fuel and labour. Drying is also more uniform than in the conventional sheds. The team is also examining closed air-circuit drying installations on the heat pump principle and an apparatus constructed by the R.A. is in operation at the National Leathersellers' College in Bermondsey. An even flow of air can be passed over the evaporator and condenser at various temperatures, humidities and velocities, to study the potentialities in drying chrome leather.

As the result of a special request from members, BLMRA has devised apparatus to permit continuous sampling of liquors in moving drums. This has been in operation for the measurement of *p*H values on a small scale for several weeks without hitch and will shortly be tested under practical conditions.

All these, though specialised in their application, are evidently in fairly conventional fields of work but a complete novelty is a project for the unhairing of hides by high speed water jets. This is still in the experimental stage, but it is hoped that successful development will provide a cleaner method than that normally in use and one therefore more acceptable to operatives.

* British Leather Manufacturers' Research Association.

DIARY

The Institution of Chemical Engineers

May 4, 5, 6. At The Dome, Brighton. International Symposium on Distillation.

The Work Study Society

April 22-24. At The Grand Atlantic Hotel, Weston-super-Mare. Working Conference on Measurement and Management.

The Society of Instrument Technology

May 24. At 26 Portland Place, London, W.1. Annual General Meeting. **6.0 p.m.** Presidential Address. **7.0 p.m.**

The Textile Institute

May 30-June 3. At Church House, Westminster. Jubilee Conference on Fibre Science.

Royal Netherlands Chemical Society, Netherlands Physical Society, and Netherlands Ceramic Society

May 30-June 4. At Amsterdam, Holland. 4th International Symposium on the Reactivity of Solids.

Electrochemical Society of the U.S.A., Electrothermics and Metallurgy Division

May 3, 4, 5. At Lasalle Hotel, Chicago, U.S.A. Conference on Methods of Reducing Iron Ores.

Other Events

April 25-29. At Empire Hall, Olympia. 1st International Compressed Air and Hydraulics Exhibition and 2nd European Fluid Power Conference.

April 25-30. At National Hall, Olympia, London. The Production Exhibition.

April 27-May 6. At Grand Hall, Olympia, London. Fuel Efficiency and Power for Industry Exhibition.

May 3-6. At Vienna. Symposium on Fuel Element Fabrication with Special Emphasis on Cladding Materials.

May 3-13. At Earls Court, London. Mechanical Handling Exhibition.

May 17-20. At Royal College of Science & Technology, Glasgow. Symposium on Nuclear Reactor Containment Buildings and Pressure Vessels.

May 23-28. At Olympia, London. Instruments, Electronics and Automation Exhibition.

May 30-June 2. At Earls Court, London. 1st International Pipes and Pipelines Exhibition.

INVESTMENT IN FUTURE OF BRITISH INDUSTRY

THE provision of practical training for up-and-coming engineers from under-developed countries by U.K. firms, was spot-lighted as a form of highly valuable investment in the future at the FBI Overseas Scholarships Scheme Annual Reunion held in London, which ended on April 1. The FBI Overseas Scholarship Scheme was introduced in 1950 with the object of providing aid in the form of practical training for graduate engineers, to the under-developed countries. Up to the present 357 engineers from 37 under-developed countries have come to the U.K. for training under the Scheme. Most of the scholars work in the United Kingdom for two years. The Scheme is administered by the FBI and the cost is shared not only by the British Government and the FBI but also by over 300 British firms who provide the training.

An important feature of the four day meeting was the Reunion Dinner on March 30. At the dinner The Right Honourable REGINALD MAUDLING, M.P., President of the Board of Trade, and MR. W. H. MCFADZEAN, President of the FBI, addressed an audience of 250 which included Ambassadors and High Commissioners from six countries, senior civil servants, 108 engineers from 30 under-developed countries, and representatives of a number of leading U.K. engineering firms.

MR. MAUDLING said he believed that one of Britain's best hopes for the future lay in facilitating world trade. Foreign engineers in Britain under the Scholarships Scheme were learning something of benefit not only to themselves but also to their own countries. What they learnt here would help them and their colleagues to develop their own industries and prosperity. The more that people knew about Britain and British products, skills, standards and techniques the more British firms would be able to trade with them.

Earlier, MR. W. H. MCFADZEAN had said British industry had a deep vested interest in the prosperity of Overseas countries. "British industry clearly recognises that the more prosperous countries provide the best opportunities for trade. There is not much future in trying to sell to an under-nourished and needy country the diverse products of Britain that are fashioned with the traditional skill of our engineers and craftsmen and that are perfected by the application of the latest British achievements of science and technology. The richest and most highly industrialised nation in the world, the U.S.A., is by far Britain's best customer."

Later, FBI Scholars replying to MR. MAUDLING gave a clue to the benefits to be reaped by British industry in training promising engineers from developing countries. MR. ABDUS SALAM, a civil engineer from Pakistan, said it would be his privilege to help in the implementation of the elaborate development plans afoot in his own country. The credit for this, he said, went largely to the FBI and the British Government who realised that countries like his own need young men, trained in their own respective sciences, who on their return to their own countries could really produce results. Speaking for the Scholars present, MR. SALAM said: "We will go back as ambassadors of good-will to strengthen the bond of friendship and understanding between our countries and Great Britain."

ERNESTO EKSTEIN, civil engineer from Sao Paulo, said Brazil needed organisation and efficient machinery to carry out its plans. It also needed engineers who had acquired the knowledge and experience to put its projects into practice and to deal with this equipment. "Our training in Great Britain is a wonderful chance of getting this knowledge and it will doubtless have an important influence in our professional futures. When we return to our own country we will be carrying with us not only British technical and administrative information, we will have something even more valuable, knowledge of the British way of life."

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Intending applicants may obtain a copy of the information sheet relating to this post from the Secretary, Association of Universities of the British Commonwealth, 36, Gordon-square, London, W.C.1.

Applications close, in South Africa and London, on 31st May, 1960.

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36th (1960) EXAMINATION

Application forms for entrance to the 1960 Examination, returnable not later than the 1st June, 1960 (1st July for those taking Part 3 (The Design Problem) only), may be obtained from The General Secretary, The Institution of Chemical Engineers, 16, Belgrave Square, London, S.W.1.

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More Engineering Per Engineer

THAT present-day society needs more engineering and can absorb all the engineering that is presented to it can scarcely be disputed. It is natural, in the circumstances, that attention should be focused upon the current shortage of engineers and upon ways of remedying this situation. But little so far has been said about another approach to this problem—the achievement of more engineering per engineer—a sign of the difficulties rather than of neglect.

There are at least two routes possible to greater engineering productivity. On the one hand we may seek to control more closely the activities of the engineer. This would require the measurement of the times taken to perform specific tasks such as literature surveys, the preparation of plant costs and the evolution of equipment designs. This information would be fed back to the engineer to the accompaniment of exhortations to produce more. To intensify the engineering effort, for this is the essence of this line of attack, without making the slightest change in its content is to offer little prospect of a lasting improvement in output. And, to many, however diplomatically were the procedure to be applied, it would savour of a status incompatible with the calling.

On the other hand, since in the vast majority of cases it is a virtual certainty that only a fraction of the engineer's time is devoted to genuine engineering, a more logical and humane approach is to free him from the less creative of his tasks. There would then be more of that precious commodity—time—in which to practise his higher functions of design, development and planning.

One obvious source of wasted effort is the mass of paper work which plagues so many engineers, especially the men at executive level. Here the remedy may derive from a careful analysis of the surrounding organisation, from a clear definition of functions and from decentralisation measures. The removal of such impedimenta is not, however, our main concern here, but rather the application of the various aids which have emerged during the last decade or so. But before many of these new tools can be used there are one or two habitual obstacles which deserve scrutiny. It is often the case, for example, that the routine side of the engineer's work is stressed at the expense of its more inventive and creative aspects and many engineers after graduation find themselves confined in their first job to purely routine activities. While this initiation is often valuable, the emphasis upon the routine aspects carries with it the risk of engendering the wrong outlook. For it may happen that the engineering task proper is regarded as consisting of a set of routines. Sometimes problems cannot be solved in any other way, but if the uncreative elements of the job are to be reduced this emphasis needs to shift, otherwise it will inhibit the use of the theoretical and practical tools now available.

In a recent paper on this subject, Harry H. Goode[1] lists a number of such aids. One of them is the important mathematical computing technique of linear programming which has proved its worth in a great variety of planning problems, an example of interest to chemical engineers being the one worked out some years ago by Charnes and colleagues[2] on the blending of gasolines in an integrated oil company. It is a tool capable of easing the costing and scheduling aspects of engineering work. Then there is the technique provided by queueing theory, of value in the making of technical decisions, which permits the analysis of events in terms of the time it takes for them to occur. Other such aids are human factors research, which is of assistance both in design and administrative work, and information theory, which, among other things, has an important part to play in the literature search operation. But of the techniques at present available, Goode considers decision theory to be the one likely to have the greatest impact upon the engineer's work, for it may well transform the whole practice of decision making.

In addition, there are a number of practical aids, the foremost being the high-speed digital computer. This machine has already revolutionised a number of engineering tasks and has made possible the solution of problems which before its advent were regarded as insoluble. The computer is remarkable, for its large memory-word storage capacities approaching 10^9-10^{10} words may soon be commonplace —a feature making possible the storage not only of large quantities of information but also the withdrawal of this information at the time it is required. This is a facility with the power of reducing greatly the work of costing, literature surveying, administration and reporting. Among other routine reducing means are such input and output devices as the high-speed printer which can exhibit great quantities of data within a brief interval of time; the oscilloscope—a means of rapid presentation and analysis of engineering curves; and finally machines for the fast reproduction of such recorded information as drawings and calculations.

Thus the employment of these devices and techniques is seen as the main path towards the goal of more engineering per engineer. Against this approach can be levelled the argument that the routine period provides him with the opportunity to think creatively about his engineering problems; it might also be said, with rather less justification, that innovators will invent whether they are given the time or not. Experience, however, favours Goode's approach, which, among other things, is an expression of confidence in the ability of the engineer to use profitably the time which his proposals would provide.

REFERENCES
[1] Paper 59-MGT-2 presented at the ASME-AIEE Engineering Management Conference September 1959.
[2] *Econometrica*, 1952, 30, 135-159.

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STEAM-STRIPPING OF CARBON DIOXIDE FROM SODA-LYE SOLUTIONS

Studies in a bubble-cap plate column show the influence on the process of variations in inlet steam and CO_2 feed rates

by D. BHARGAVA, G. N. BHAT and E. WEINGAERTNER*

THE manufacture of pure carbon dioxide consists of processes in which the CO_2 component of the CO_2-rich gases obtained from combustion of industrial gases or from fermentation industries as by-products is absorbed in a solution of sodium or potassium carbonate and bicarbonate. The lye solution thus obtained is boiled to release CO_2, which is subsequently recovered from the accompanying steam by condensation of the latter. While considerable attention has been paid to the absorption step of this process,[1, 2, 3, 21, 22] very little information is available on the stripping part, and hence a series of investigations was undertaken to study the stripping process.

Theoretical Considerations

The desorption of CO_2 from lye solutions is expected to occur in the following consecutive steps: (i) bicarbonate decomposes, releasing CO_2 in a water-soluble state; and (ii) the dissolved CO_2 then diffuses from the main body of the liquid phase into the main body of the gas phase through the liquid-gas interphase.

Accordingly, the overall rate of desorption would be controlled to different degrees by the rate of decomposition of bicarbonate and the rates of diffusion of CO_2 in the liquid and the gaseous phases.

J. W. Payne and B. F. Dodge[4] have suggested the following steps in which the CO_2 absorption into and desorption from alkali solutions may possibly be occurring:

$$CO_2\ (\text{gas}) \rightleftharpoons CO_2\ (\text{dissolved}) \qquad \text{(i)}$$

$$CO_2\ (\text{dissolved}) + H_2O \rightleftharpoons H_2CO_3 \qquad \text{(ii)}$$

$$H_2CO_3 \rightleftharpoons H^+ + HCO_3^- \qquad \text{(iii)}$$

$$H^+ + HCO_3^- \rightleftharpoons 2H^+ + CO_3^{=} \qquad \text{(iv)}$$

$$H^+ + OH^- \rightleftharpoons H_2O \qquad \text{(v)}$$

$$CO_2\ (\text{dissolved}) + OH^- \rightleftharpoons HCO_3^- \qquad \text{(vi)}$$

$$HCO_3^- + OH^- \rightleftharpoons CO_3^{=} + H_2O \qquad \text{(vii)}$$

$$CO_2\ (\text{dissolved}) + 2\,OH^- \rightleftharpoons CO_3^{=} + H_2O \qquad \text{(viii)}$$

Of the above reactions, those which are slow enough would control the overall rate of mass transfer. Although there is difference of opinion as to which of these reactions are the slower controlling steps, the overall rate of decomposition observed is not rapid[5]; the reaction steps which are not ionic, such as the diffusion of molecular CO_2 within the liquid phase, are sufficiently slow so that equilibrium conditions are always reached in the ionic reactions. Studies

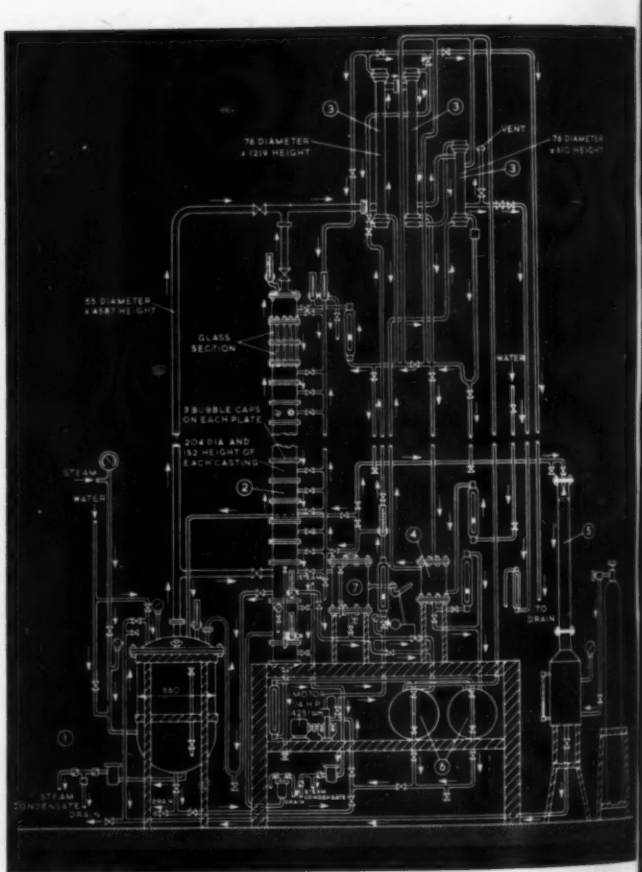

Fig. 1. Bubble-cap plate column assembly. (1) Kettle with closed-steam/cooling-water coil. (2) Bubble-cap plate column with 20 plates. (3) Vertical tubular condensers. (4) Condensate cooler, 264 dia. × 266 height. (5) Packed absorption column. (6) Receivers, 419 dia. × 610 length. (7) Tank with float controlling bottoms level in the plate column.

* Department of Chemical Technology and Chemical Engineering, Indian Institute of Science, Bangalore-12.

TABLE I—Data on Plate Efficiencies and Liquid-phase Mass-transfer Coefficients Obtained at Different Steam and CO_2 Feed Rates

Run No.	Steam feed rate	CO_2 feed rate	Murphree Plate Efficiency								Overall Liquid-phase Mass-transfer Coefficient K_L
			Plate 1	Plate 2	Plate 3	Plate 4	Plate 5	Plate 6	Plate 7	Overall Plate Efficiency	kg mol/hr / m.²(kg mol/m.³)
	kg/hr	kg/hr	%	%	%	%	%	%	%	%	
15	14.29	0.1416	84.0	94.2	47.6	26.3	43.0	28.7	39.3	39.0	0.1096
16	14.95	0.1831	11.9	56.1	19.4	17.6	29.0	13.9	33.5	18.9	0.0387
17	14.83	0.2364	27.2	57.0	37.7	16.9	38.2	21.6	18.9	24.5	0.0624
18	14.98	0.2870	8.7	47.5	33.1	64.6	44.4	9.9	20.4	18.7	0.0603
19	14.01	0.3458	18.8	13.4	12.7	11.4	21.4	19.1	8.6	12.0	0.0435
8	24.46	0.1375	43.5	44.0	70.1	66.2	21.9	43.0	30.8	32.8	0.0503
9	24.42	0.1815	40.8	71.6	20.8	32.1	26.5	33.1	16.9	23.0	0.0609
13	24.04	0.2387	36.5	14.9	50.6	37.8	29.3	28.3	19.4	22.2	0.0524
10	24.26	0.2201	74.0	40.0	33.4	27.7	62.9	25.2	15.0	29.3	0.0931
11	24.72	0.2852	10.3	43.8	40.0	15.6	13.3	23.9	22.4	17.1	0.0445
12	24.46	0.3571	40.4	25.5	15.8	27.7	12.1	30.0	26.9	14.7	0.0670
21	25.30	0.4611	14.8	21.4	14.3	13.4	23.2	20.2	25.5	13.7	0.0507
5	36.22	0.1289	30.4	21.7	11.4	43.8	44.9	19.0	29.6	16.8	0.0244
6	37.05	0.1856	35.9	39.2	22.7	20.4	34.3	31.6	17.8	18.4	0.0333
14	34.93	0.2271	12.5	35.8	20.3	19.0	15.9	26.6	24.8	14.1	0.0301
7	35.23	0.3364	31.3	27.7	16.3	28.0	26.1	18.0	8.6	14.2	0.0445
20	36.89	0.5043	6.9	15.8	14.9	5.0	24.9	11.6	11.6	10.5	0.0336

TABLE II—Calculated Values of Interfacial Area and Liquid-phase Mass-transfer Coefficients from Reported Data

Curve No. in figure of this paper	Authors	Reference Number	Operation studied	Liquor rate L	Overall liquid phase mass-transfer coefficient K_La	Interfacial area a	Overall-liquid-phase Mass-transfer coefficient $K/_L$
				kg/hr	kg mol/hr / m.³ (kg mol/m.³)	m²/m³ of packed volume	kg mol/hr / m.² (kg mol/m.³)
1	F. F. Rixon	23	Absorption	2325	2.45	11.83	0.2239
				13,800	9.16	16.52	0.5545
2	H. V. Allen	24	Absorption and Desorption	12.3	4.39	11.83	0.3571
				102.0	10.36	16.52	0.6271
3	D. W. Deed *et al.*	25	Desorption	15.1	1.23	3.35	0.3664
				310.0	26.94	8.81	3.0583
4	F. F. Rixon	23	Desorption	1120	1.54	7.25	0.2126
				6120	8.39	14.53	0.5774
5	T. K. Sherwood *et al.*	22	Desorption	760	0.72	5.08	0.1490
				9100	7.25	13.30	0.5447
6	T. K. Sherwood *et al.*	26	Desorption	200	0.62	2.44	0.2556
				32,000	90.16	82.29	1.0947
7(a)	H. A. Koch *et al.*	27	Desorption	38.1	0.79	5.08	0.1560
				531.7	8.07	13.30	0.6066
7(b)	H. A. Koch *et al.*	27	Desorption	106	0.79	5.08	0.1560
				1485	13.90	29.91	0.6066
8	C. S. Cantello *et al.*	28	Absorption	59	0.95	16.91	0.1375
				670	4.01	13.44	0.2980
9	C. W. Simmons *et al.*	29	Absorption	49	1.18	6.57	0.1800
				178	3.88	17.47	0.2220
10	E. W. Blair *et al.*	30	Absorption	800	34.86	5.24	6.65
				1600	13.79	6.90	2.00

by S. Hatta and M. Katori,[6] C. S. Comstock and B. F. Dodge[1] and V. V. Vyazvov[7] have shown that at temperatures lower than those used in steam-stripping the diffusion of CO_2 in the liquid phase is very much slower than in the gaseous phase. It is evident, therefore, that in this desorption process the liquid-phase reactions are the rate-controlling steps.

Literature Survey

Studies on the absorption of CO_2 in alkaline solutions have been extensively carried out with a view to determining the influences of the various variables on the mass transfer involved. In general, the overall mass-transfer coefficient K_Ga was found: (1) to increase with liquor rate to its 0.28[8] or 0.84[9] power, with liquid-temperature to its 0.6 power[8], and with solution pH[1] and sodium normality up to a normality of about 2[8, 9]; (2) to decrease with increasing liquid viscosities,[8] with bicarbonate concentration,[1, 2, 8, 13] and with sodium normalities greater than about 2[8, 9, 10, 11]; and (3) to be independent of gas rates,[1, 9] of packing sizes[9] and of CO_2-concentration in the gas phase.[1, 9] However, K_Ga has also been reported to be increasing as the 0.53 power of gas rate[12] and to be decreasing with liquor mass velocities in a certain velocity range.[13] The only set of data[14] reported on the CO_2 absorption using a bubble-cap plate column indicates the Murphree plate efficiency to be 7%.

On the other hand, information regarding desorption of CO_2 from lye solutions is quite rare. Results obtained by W. G. Whitman and G. H. B. Davis[14] on the steam-stripping of CO_2 using a bubble-cap plate column indicated the coefficient of desorption to be 2.4 times greater than that for absorption. Of late, the use of hot carbonate process for the removal of CO_2 has acquired considerable importance, since it has been found particularly useful in systems wherein the CO_2 has to be removed at comparatively higher pressures. The gas mixture is treated at about 100 to 300 psig with hot K_2CO_3 solution whereby CO_2 is absorbed. The alkali solution is regenerated by reducing the pressure, and the released CO_2 is recovered. A review describing the economic advantages of this process appeared recently.[33] The operating data of two industrial plants operating for some time has also been published.[34] Experiments reported by H. E. Benson, J. H. Field and W. P. Haynes[15] on the recovery of CO_2 from K_2CO_3-$KHCO_3$ solutions, using a packed column, indicate substantial heat savings when counter-current steam-stripping is employed. Recently, F. J. Young and M. M. David[16] have carried out mass-transfer studies on the counter-current steam-stripping of CO_2 from soda-lye solutions in a wetted-wall column. These authors report that (1) the overall mass-transfer coefficient, K_G, is independent of lye and steam-rates over the two-fold and the two-and-a-half-fold variations in the respective rates

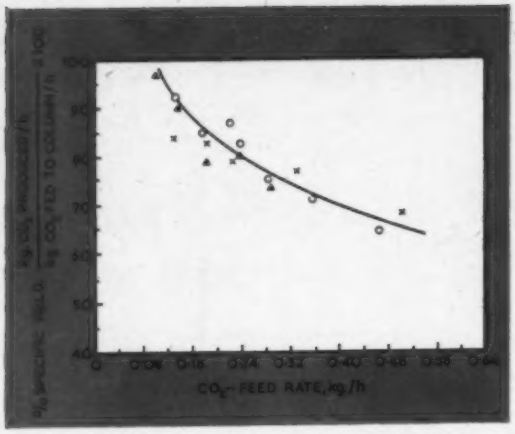

Fig. 2. Variation of specific yield with CO_2 feed rate.

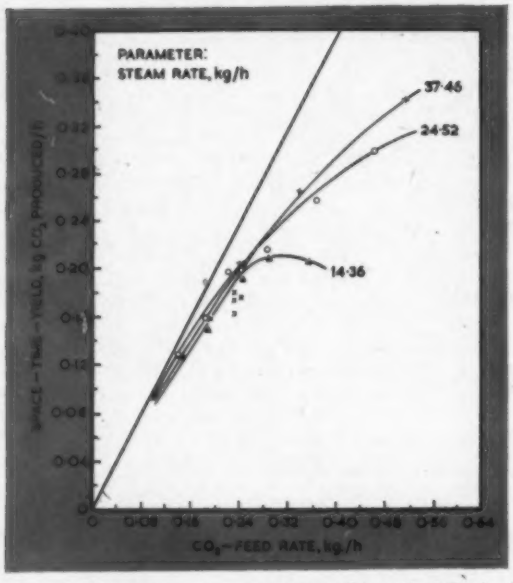

Fig. 3. Variation of space-time-yield with CO_2 feed rate.

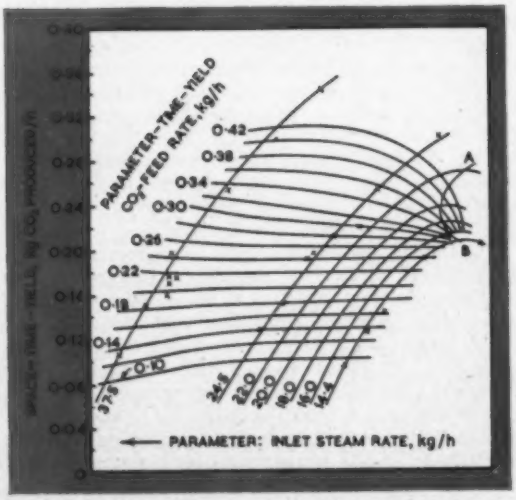

Fig. 4. Nomographic chart showing space-time-yield as a function of CO_2 feed rate and inlet steam rate.

studied, but it would decrease with increase in sodium normalities; (2) that the major resistance to mass transfer is in the liquid phase and is probably associated with the decomposition rate of the bicarbonate; and (3) that wave formation and bubble formation in the liquid film may also play a prominent role in determining the mass-transfer rate.

From an overall consideration of the above review, it is obvious that the rate of mass transfer in the system CO_2-lye solution is controlled primarily by the resistances of the liquid phase processes, and hence a plate column would be preferable for carrying out such operations. Further, the use of plate column and direct steam for stripping will provide as many mass- and heat-transfer stages as the number of plates provided in the column employed, as against the uni-stage operation of the lye-boiler practice ordinarily used for such processes. Operating variables likely to influence the rate of stripping seem to be the inlet rate, sodium normality and initial bicarbonate concentration of the feed lye, as well as the inlet steam rate to a certain extent.

This paper presents data on the effects of inlet lye and steam rates on such stripping operations.

Apparatus and Procedure

The bubble-cap plate column used in the study was the bottom-8-plate section of a 20-plate column constructed by M/s. Brighton Copper Works Inc., Cincinnatti, U.S.A. This portion of the column used in these investigations was made of copper and was lagged with fibre-glass. The plates cast out of bronze were of 194 mm i.d., and each plate had three bubble-caps placed on a 76-mm equilateral triangular pitch. Each cap was 51 mm o.d. and 47 mm i.d. and had 32 slots each 11 mm high and 2.5 mm wide. Three condensers were used for separating the released CO_2 from the accompanying steam. The first one was also used as a preheater for the incoming strong lye, while cooling water was circulated through the latter two. The complete assembly of the unit is shown in Fig. 1.

Flow rates of strong lye, weak lye and cooling water were measured with calibrated rotameters. The inlet steam rates were determined by orificemeters, installed and calibrated as given in Kopper's Handbook.[17] Inlet lye rates were varied from about 10 to 50 kg/hr for each inlet steam rate of 14.5, 24.5 and 37.5 kg/hr.

The total sodium normality of the feed lye used during each of the runs was about 1.0, with about 42% of the total sodium present as bicarbonate, the concentrations of sodium carbonate and bicarbonate, therefore, being about 32 and 37 g./l. respectively. Before feeding the lye, the column was at a pressure of 10 mm Hg gauge. Under steady-state operating conditions the column pressure was between 55 and 60 mm Hg gauge and the average column temperature was 98.5°C during each of the runs. Before starting a stripping run, the column was brought to steady temperature conditions by feeding steam at the bottom of the column at the desired rate and temperature conditions. The rate of cooling water to condensers was so adjusted as to obtain the condensate at as high a temperature as possible in order to minimise the dissolution of CO_2 in the condensate, thereby avoiding unnecessary losses of CO_2. The strong lye, preheated to 45°C in the kettle by closed steam, was pumped to the first condenser at the desired rate, where it was further preheated to about 80 to 85°C. The lye solution was then fed into the column between the eighth and the ninth plates. When steady-state conditions were attained, lye samples were taken from the kettle and from each of the plates and analysed for their Na_2CO_3 and $NaHCO_3$ contents by titration with HCl to the phenolphthalein and methyl-orange end points. CO_2 contents in the exit gas samples from the last condenser to the gas holder were determined by analysis using Hay's gas

analysis apparatus. Amounts of CO_2 in the steam condensate samples were also estimated by precipitating the CO_3 components as $BaCO_3$ by the addition of excess $Ba(OH)_2$ solution and back-titrating the excess with standard HCl.

With the data obtained, material and energy balance checks were made during every run.

Results and Discussion

Data on different experimental conditions employed during the various runs and the calculated data from the experimental results are given in Tables I and III.

The calculated data were graphically presented in such a way as to indicate the influence of variations in inlet steam and CO_2 feed rates under steady-state operating conditions on: (a) the specific yield which is the quantity of CO_2 produced per unit quantity of CO_2 fed to the column in the form of $NaHCO_3$ in the feed lye; (b) the space-time-yield, defined as the quantity of CO_2 produced from the system per hour; (c) the Murphree and the overall plate efficiencies; and (d) the overall liquid-phase mass-transfer coefficients.

Though the mechanism of mass-transfer accompanied or preceded by chemical reaction on bubble-cap plates has not yet been properly treated, the following considerations may be helpful in understanding the results obtained in the present study.

According to D. Hammerton and F. H. Garner,[18] gas-liquid contacting during bubbling, except for bubbles smaller than 0.4 cm diam. can be treated by Higbie's[19] concept. Based on this and including his observations of chain bubbling in the range of gas rates between 20 and 250 cu. cm per slot, and a constant bubble frequency of 20 per sec., P. H. Calderbank[20] has treated the phenomenon of physical mass transfer during bubble-formation and during bubble-rise. Velocities of bubble-rise were found to increase with increasing gas rates and, correspondingly, the contact times to decrease. Conversely, with an increase in liquid rates, the residence time of the liquid was found to decrease. Thus, applied to our system, increasing steam and lye rates will adversely influence mass transfer due to the reduced time of contact.

However, there are other factors dependent upon the increase in rates, which tend to rather favour mass transfer; namely, increase in total interfacial area and rate of surface renewal, disturbance of interfacial surface and turbulence of liquid flow.

These partly favourable and partly unfavourable factors governing mass transfer will, therefore, result in an outweighed overall effect under different sets of circumstances. However, the degree to which each of these different effects, namely, changing steam and lye rates, will influence mass transfer, cannot yet be predicted, especially as their influence may further be affected by other operating conditions. If the time of residence were the only influential variable, a linear decrease in specific CO_2 yield with increase in feed rates could be expected. However, as can be seen from Fig. 2, a relationship with a continuously decreasing slope is obtained. One would expect this to arise from a steadily decreasing resistance to mass transfer, on account of the more favourable effect of other influential factors governing mass transfer, e.g., liquid-phase turbulence, rate of surface renewal, etc. It can further be seen from Fig. 3 that at any of the CO_2 feed rates up to 0.24 kg/hr, at different steam rates no differences in the space-time yields have been found. This would seem to indicate that within this region opposing influences on mass transfer from increasing steam rates, as mentioned above, must be almost of the same magnitude. However, at any CO_2 feed rate greater than 0.24 kg/hr space-time-yields obtained will also increase with increasing steam rates. This observation shows that, under these conditions, the favourable influence of increased

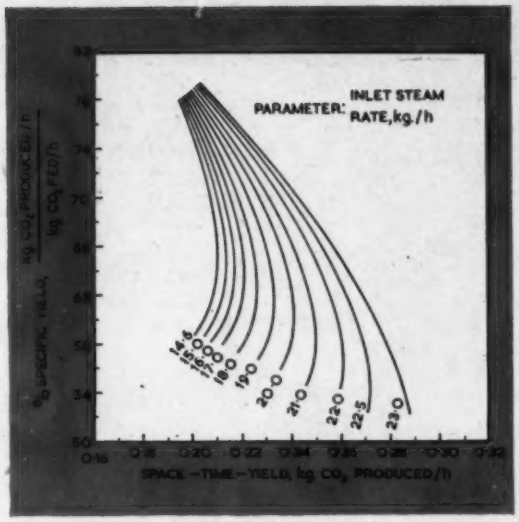

Fig. 5. Variation of % specific yield with varying space-time-yield for interpolated values of steam rates.

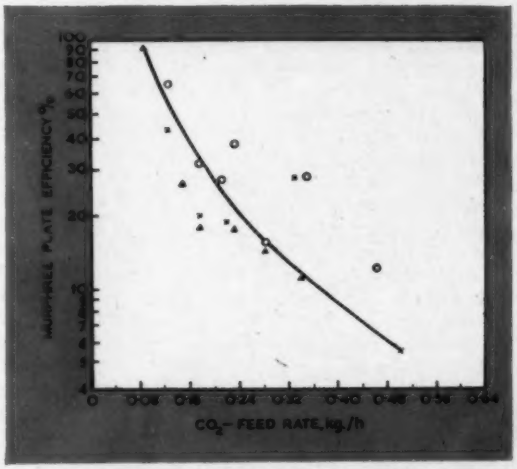

Fig. 6. Variation of Murphree plate efficiency with CO_2 feed rate for plate 4.

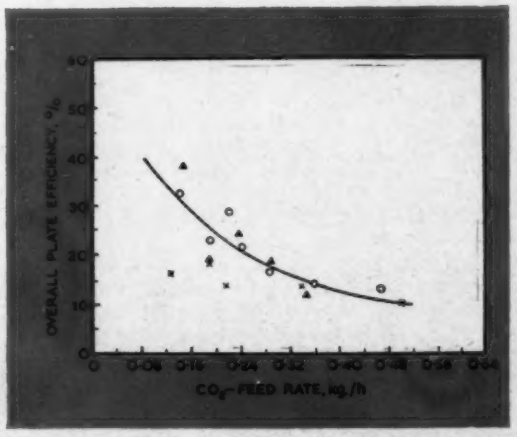

Fig. 7. Variation of overall plate efficiency with CO_2 feed rate.

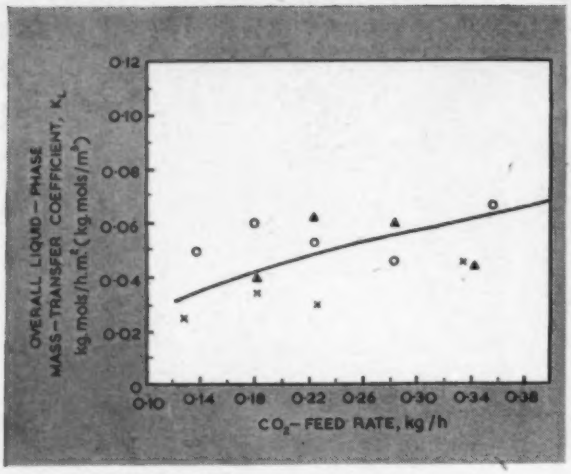

Fig. 8. Variation of overall liquid-phase mass-transfer coefficient with CO_2 feed rate.

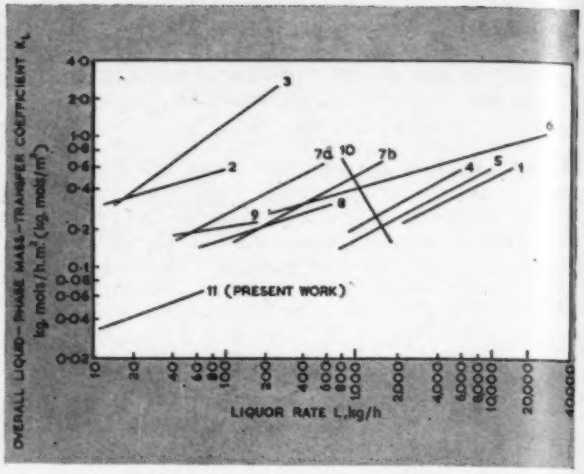

Fig. 9. Comparison of overall liquid-phase mass-transfer coefficient K_L with those in Table II.

turbulence and surface renewal is more pronounced than the adverse effect of decreased time of residence of the vapour.

Data presented in Fig. 3 have been used to obtain a nomographic chart as shown in Fig. 4. These representations show that at any one particular steam rate the space-time-yields increase with increasing CO_2 feed rate, reaching a maximum and then decrease with further increase in CO_2 feed rate. These maxima are obtained for any given steam rate at a particular CO_2 feed rate. Therefore, the CO_2 feed rates at which maximum space-time-yields are obtained, are functions of steam rates. It is further obvious that decreases in space-time-yield subsequent to such maxima are caused by changed desorption conditions due to partial condensation of steam used for heating the lye. Under such conditions less steam than that admitted into the column will be available as stripping agent, with consequently reduced release of CO_2 from the lye. A further change of conditions will also occur owing to dilution of feed lye by steam condensate. Therefore, at any particular steam rate, conditions prevailing in the region of high CO_2 feed rates should also disfavour mass transfer. In this region, increased CO_2 feed rate would further tend to decrease the time of residence of the lye in such a way that it may become the governing influence on mass transfer.

Fig. 5 shows the variation of space-time-yield with corresponding changes in specific yields for different steam rates. From this representation it becomes clear that for every steam rate there exists one operational condition signified by the highest possible space-time-yield, but in disfavour of the highest specific yield. This observation has important technical consequences. If one has to deal with a very costly product but a less costly plant, the operational trend will be biased towards obtaining high specific yields with correspondingly reduced space-time-yield or product output. On the other hand, in the case of a comparatively cheaper product but a costly equipment, the operational tendency will be directed more towards obtaining the highest possible space-time-yield with reduced specific yield. All operational conditions will, however, lie within these limiting factors. For the system under investigation, namely CO_2 stripping from soda lye solutions using bubble-cap plate columns, where the lye is not so highly valuable, while the equipment is costly with its correspondingly higher depreciation, emphasis will have to be laid on securing high output rather than achieving a particularly high specific yield. Therefore, the tendency will be to work closer to maximum space-time-yield conditions for a given steam rate, and the steam rate itself should be as high as possible in order to maintain the overall output at the highest level.

Both Murphree and the overall plate efficiencies obtained give the most proper indications of efficiency of mass transfer. P. H. Calderbank[20] has shown that the efficiency of mass transfer on bubble-cap plates during bubble-formation depends upon the diffusivity of solute gas through the liquid phase, and that during bubble-rise period it is dependent on the gas rate to its (0.33) power and on the liquid rate to its (−1) power. Thus, the results obtained in the present investigations represented in Figs. 6 and 7 are in agreement with these observations and show greater dependence of plate efficiencies on CO_2 feed rates rather than on steam rates.

Data presented in Fig. 8 show that the effect of CO_2 feed rate variation on overall liquid-phase mass-transfer coefficient is due to increased liquid turbulence and solute gas diffusivity through the liquid film at high CO_2 feed rates. The scattering of points in Fig. 8 may be due to the assumption made while evaluating K_L values by the method proposed by T. K. Sherwood and R. L. Pigford.[21] A comparison shown in Table II and Fig. 9 of the K_L values obtained in the present investigation with those of previous workers indicates the present results to be of a similar trend as reported.[22, 23]

TABLE III—Maximum Space-time-yields and Specific Yields Possible and Corresponding CO_2 Feed Rates at Different Steam Rates

Steam rate	Maximum Space-time-yield obtained	Corresponding CO_2 feed rate	Corresponding specific yield
kg/hr	kg/hr	kg/hr	%
14.4	0.2115	0.3100	68.23
15.0	0.2132	0.3135	68.00
16.0	0.2168	0.3246	66.80
17.0	0.2201	0.3335	66.00
18.0	0.2245	0.3454	65.00
19.0	0.2298	0.3659	62.80
20.0	0.2371	0.3952	60.00
21.0	0.2472	0.4200	58.86
22.0	0.2615	0.4670	56.00
22.5	0.2710	0.4900	55.31

REFERENCES

[1] Comstock, C. S., and Dodge, B. F. *Ind. Eng. Chem.*, 1937, **29**, 520.
[2] Harte, C. R., Jr., and Baker, E. M. Ibid., 1933, **25**, 1128.
[3] Sherwood, T. K., and Pigford, R. L. "Absorption and Extraction", second edition, McGraw Hill Book Co. Inc., New York, 1952.
[4] Payne, J. W., and Dodge, B. F. *Ind. Eng. Chem.*, 1932, **24**, 630.
[5] Tsuchiya, R. J. *J. Chem. Soc.*, Japan, Pure Chem. Sec., 1953, **74**, 12.

[6] Hatta, S., and Katori, M. *J. Soc. Chem. Ind.*, Japan, 1934, **37**, 280B.
[7] Vyazvov, V. V. *J. Tech. Phys.* (U.S.S.R.), 1940, **10**, 1519.
[8] Tepe, J. B., and Dodge, B. F. *Trans. Amer. Inst. Chem. Eng.*, 1943, **39**, 255.
[9] Blum, H. A., Stutzman, L. F., and Dodds, W. S. *Ind. Eng. Chem.*, 1952, **44**, 2969.
[10] Mitsukuri, S. *Sci. Pep. Tohoku Imp. Univ.*, 1929, **18**, 245.
[11] Ledig, P. G., and Weaver, E. R. *J. Amer. Chem. Soc.*, 1924, **46**, 650.
[12] Furnas, C. C., and Bellingar, E. *Trans. Amer. Chem. Soc.*, 1938, **34**, 251.
[13] Greenwood, K., and Pearce, M. *Trans. Inst. of Chem. Eng.*, 1953, **31**, 201.
[14] Whitman, W. G., and Davis, G. H. B. *Ind. Eng. Chem.*, 1926, **18**, 264.
[15] Benson, H. E., *et al. Chem. Eng. Prog.*, 1956, **52**, 433.
[16] Young, F. J., and David, M. M. "The Trend in Engineering at the University of Washington", Seattle, January 1957, p.13.
[17] "Koppers Handbuch der Brennstofftechnik", 1953 edition, 173-9.
[18] Hammerton, D., and Garner, F. H. *Trans. Inst. of Chem. Eng.*, 1954, **32**, 818.
[19] Higbie, R. *Trans. Amer. Inst. Chem. Eng.*, 1931, **31**, 365.
[20] Calderbank, P. H. *Trans. Inst. of Chem. Eng.*, 1956, **34**, 79.
[21] Sherwood, T. K., and Pigford, R. L. "Absorption and Extraction", second edition, McGraw Hill Book Co. Inc., New York, 1952, pp. 227-9.
[22] Sherwood, T. K., *et al. Ind. Eng. Chem.*, 1937, **29**, 282.
[23] Rixon, F. F. *Trans. Inst. Chem. Eng.*, 1948, **26**, 119.
[24] Allen, H. V. Thesis in Chem. Eng., M.I.I., U.S.A., as reported by T. K. Sherwood and F. A. Holloway in Reference No. 26.
[25] Deed, D. W., *et al. Ind. Eng. Chem.*, 1947, **39**, 766.
[26] Sherwood, T. K., and Holloway, F. A. L. *Trans. Amer. Inst. Chem. Eng.*, 1940, **36**, 21, 39, 181.
[27] Koch, H. A., Jr., *et al. Chem. Eng. Prog.*, 1949, **45**, 677.
[28] Cantello, C. S., *et al. Ind. Eng. Chem.*, 1927, **19**, 989.
[29] Simmons, C. W., and Osborne, H. R. Ibid., 1934, **26**, 529.
[30] Blair, E. W., *et al. J. Soc. Chem. Ind.*, 1923, **42**, 235-7.
[31] "Absorption of CO_2 in Carbonate-Bicarbonate Buffer Solutions in a Wetted-wall column" by R.A.T.O. Nysing and H. Kramers presented at the twelfth meeting of the European Federation of Chemical Engineering, Amsterdam, May 7-9, 1957.
[32] Danckwerts, P. V., and Kennedy, A. M. *Chem. Eng. Science*, 1958, **8**, 201.
[33] Buck, B. O., and Leitch, A. R. S. *Pet. Ref.*, 1958, **37**, 11, 241-6.
[34] Polo, R. O., and Armstrong, J. B. Ibid., 1958, **37**, 12, 123-8.

International Discussion on the Utilisation of Oil Shale Fines*

IN the year 1951 O.E.E.C. organised a Technical Assistance Mission of eleven experts from eight countries to visit Kvarntorp, near Örebro in Sweden, to make a study of the methods and equipment employed in the Swedish shale oil industry. The report of the mission formed the subject of the O.E.E.C. publication No. 93.

As a result of the policy of the European Productivity Agency to encourage European co-operation in applied research, a meeting of shale oil experts was held on October 20 and 21, 1959, to discuss the utilisation of oil shale fines.

Apart from a very few notable and short-lived exceptions, shale oil is produced by heating broken oil shale in closed retorts of various designs. The organic matter in the oil shales breaks down at temperatures of 450 to 650°C to yield oil, gas, water and sometimes ammonia compounds. As the heating of the oil shale during retorting is usually carried out largely by means of hot gases, the shale must be carefully graded to permit the free passage of the heating gases and the ready removal of the products of distillation. This may involve the screening of the crushed oil shale to remove fines, and depending on the type of shale and so on, these fines may amount to as much as 25% of the total shale.

The importance of the utilisation of oil shale fines is well known to those engaged in the industry, and when the E.P.A. suggested having a technical discussion on the subject, delegates from six countries expressed their willingness to take part. The meeting took place in Paris at the Château de la Muette, and the subject was discussed informally by delegates from Italy, the Netherlands, Spain, Sweden, the United Kingdom and the United States of America. The meeting was opened by Dr. King, Deputy Director of E.P.A. Dr. D. Stewart, the U.K. delegate, presided over the technical session.

The delegates from each country represented first described the conditions peculiar to their own existing or potential shale oil industry. The fact emerged that no generally accepted means of making use of the fines was available. It was agreed that such a process was desirable particularly where the shale was friable and the proportion of fines was high as in Sweden, or where the cost of mining the shale formed an important part of the cost of production of oil, as in Scotland and Spain.

The possible methods of disposing of oil shale fines were discussed, and these varied from dumping the fines to retorting them in an old mine shaft and their utilisation in cement making. The more conventional methods of distillation for the recovery of oil were also discussed and it was agreed that no satisfactory retort was available to industry capable of handling small shale for oil recovery.

From the discussion, it became evident that there were three schools of thought regarding oil shale fines:

(1) In the first group, the low cost of mining and retorting discouraged any consideration of a separate process for handling fines, should it be found necessary to separate these from the bulk shale. This was particularly true if the nature of the shale was such that only a small proportion of fines was formed by crushing and handling of the mineral. The principal member of this group was likely to be the future Colorado shale oil industry.

(2) In the second group, the cost of mining was such that the dumping of shale fines represented a considerable financial loss, even though their separation facilitated the operating of the retorting plants. This applied particularly to the existing industries in Scotland and Spain. The delegates from both these countries had experimented with the briquetting of shale fines with a view to recovering the oil from these in a conventional retort for large shale. It had been found possible to make briquettes on both extrusion and wheel press machines. In Scotland several tons of these briquettes had been successfully retorted along with large shale in an existing retorting plant. A full-scale plant to briquette accumulated shale fines and to recover oil was being planned.

(3) In the third group the nature of the shale and the type of retort used to process it was of overriding importance—considerations which at the moment applied more particularly to the Swedish shale oil industry. In Sweden the shale is found near the surface and is comparatively friable. The type of retorts used require that the shale should be separated into size grades varying from ¼ in. to 1 in. Screening after crushing is therefore a major process, and up to 25% of fines may be obtained. The rejection of such a large proportion of the shale, while representing a loss of oil, also represents a considerable loss of potential heat and energy in the free carbon typical of this shale.

The Swedish delegates described experiments which they had carried out towards the development of a two-vessel fluidised process for recovering oil from Swedish oil shale fines by direct contact with hot spent shale. The de-oiled shale from the pyrolysis unit is fluidised with air to produce the process heat, after which further fluidisation with oxygen and steam in a third vessel will produce synthesis gas from the remaining carbon. Small-scale work on this process had been so encouraging that a two-ton-per-day pilot plant is being developed. The Aspeco retorting process was described by a Swedish delegate, but this plant, although of Swedish origin, is being developed in America and does not find favour with the Swedish industry.

One of the functions of E.P.A. is to encourage and aid the carrying out of co-operative research on agreed technical subjects, but the meeting decided that in this instance such co-operative research was undesirable owing to the varied nature of oil shale and the peculiarities of the industries involved. Instead, it was agreed that a meeting should be held in two or three years' time to discuss the results of treating shale fines by the methods proposed at the present meeting.

* This note was written by Dr. D. Stewart, the sole U.K. delegate to the meeting, and has been approved by the other delegates who attended.

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FLUIDISED ROASTING OF PYRITES

Competing with the modern multi-hearth furnace methods, this process yields cinders suitable for the iron and steel industry

METHODS of roasting pyrites have undergone a great change and this has extended considerably its economic and technical advantages. Until recently, it was sufficient to obtain the maximum recovery of the sulphur content of the mineral in the form of sulphurous gases normally used for the manufacture of sulphuric acid. However, limiting the objective in this way could, in a very short time, eliminate pyrites as a raw material due to the enormous quantities of low-price elemental sulphur on the market. For this reason, the introduction of other by-products into the economic balance of the process has been necessary. The chief ones are:

(1) recovery of the energy given off from the heat of reaction; and
(2) iron oxide obtained as cinders.

Desirable Conditions [1]

For a good roasting of pyrites, the following six conditions are required:

(a) the production of all the iron as ferric oxide suitable for the iron and steel industry and in a state ready for leaching and eventual sintering;
(b) the removal of the arsenic and lead from the pyrites in the roasting gases;
(c) leaving the useful metals, copper and zinc, which are "impurities" in the cinders, as soluble sulphates;
(d) obtaining gases with the maximum possible concentration of sulphur dioxide and the minimum possible concentration of sulphur trioxide;
(e) making the maximum use of the heat of reaction; and
(f) maximum economy in the capital expenditure

TABLE I—Economic Comparison of the Processes of Roasting Pyrites
Cost in £/Ton of Useful Pyrite Roasted

Raw Material: Arsenical pyrites.
As 0.5%, Cu 0.8%, basis 46% S.
Equivalents: £1 = 2.8 U.S. $ = 11.76 D.M. = 168 Ptas.

Plan capacity: 160 tons/day
Working days: 330 in the year
Plant location: English coast

Roasted with	Multi-hearth furnaces		Fluidised-bed furnaces	"P.E." Fluidised-bed furnaces	
	Without heat recovery	With heat recovery	One stage	Model 2	Model 22
Unit capacity tons/day	40	40	80	80	80
Total cost of plant £[1]	217,000	285,000	200,000	214,000	248,000
Costs, £ s. d.					
Useful pyrite	4 5 0	4 5 0	4 5 0	4 5 0	4 5 0
Unprofitable pyrite	6 9	6 9	3 6	3 6	6 9
Operating costs	13 3	13 3	13 0	14 3	17 3
Capital cost	19 9	1 6 0	18 3	19 6	1 2 6
Total £ s. d.	6 4 9	6 11 0	5 19 9	6 2 3	6 11 6
Credits, £ s. d.					
Steam	—	7 6	12 6	11 6	11 6
Cinders[2]	1 15 3	1 15 3	—	1 11 3	2 6 0
Total £ s. d.	1 15 3	2 2 9	12 6	2 2 9	2 17 6
Cost of equal quantity SO_2, £ s d.	4 9 6	4 8 3	5 7 3	3 19 6	3 14 0
Comparison £/ton of pyrite roasted	Loss −1.3	Basis —	Loss −19.0	Gain +8.9	Gain +14.3

[1] The capital expenditure represents the total cost of the corresponding roasting plants with furnaces, boilers (except in the case of hearth furnaces without heat recovery), electro-filters and includes buildings, transport, installations, storage of pyrites and cinders on the plant site, platforms, ladders, distribution of electric power, etc.
[2] The cinders are valued—when they are used in the iron and steel industry—for their iron and copper content.

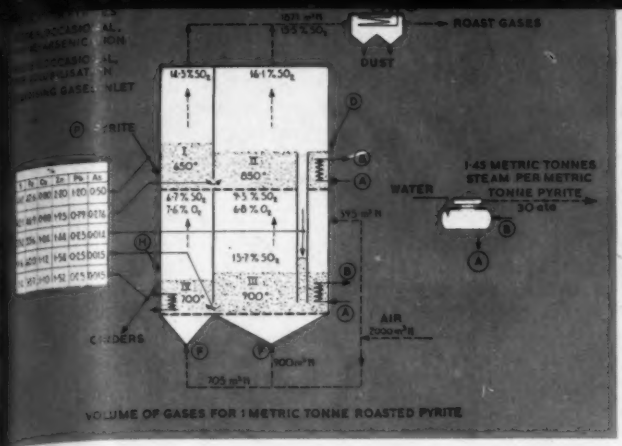


Fig. 1. Flow diagram of two-bed process for the elimination or arsenic and lead from pyrites.

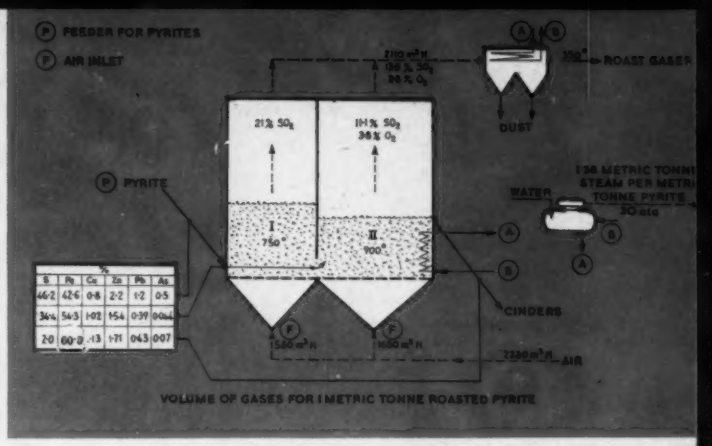


Fig. 2. Flow diagram of a single-bed process arrangement for the de-arsenification of pyrites.

needed to comply with the five preceding conditions; this is achieved by increasing the unit capacity of the furnace.

Methods in Use for the Roasting of Pyrites

The six fundamental conditions given above cannot be met when treating Spanish pyrites by any of the present roasting methods. Their most interesting technical characteristics are summarised, in a general way, in the table giving the principal functional characteristics of the furnaces used for the roasting of pyrites.

From a study of the preceding table, it is evident that the most advantageous technical solution is turbulent roasting carried out in a two-stage fluidised-bed furnace; this method is used in Germany, the U.S.A. and Spain. If heat recovery is not desired, which today is almost a technical heresy, multi-hearth furnaces show the advantage of having been established in industry for over 40 years. However, this advantage is obtained at the expense of the considerable capital outlay required by their installation, bearing in mind that the furnace capacity required to deal with 1 ton/day of pyrites is 13 times greater than that required by a fluidised-bed furnace.

The "Piritas Españolas" Process [2]

It is well worth noting that the same method of solving this problem has been adopted by both the most advanced countries in the technical field of pyrites roasting (Germany and the U.S.A.) and the one most interested in solving it namely Spain, the owner of the world's largest mass of pyrites, but containing a considerable amount of arsenic.

It has been possible for "Piritas Españolas" (Empresa Auxiliar de la Industria, S.A.) to make considerable progress in the research work, due to their discovery of a fundamental fact. The oxidation of arsenic sulphide—which is the form in which the arsenic in the pyrites is given off when it comes into contact with the hot turbulent layer—is not due to excess air but to reaction of arsenic sulphide with ferric oxide, fluidised bed's chief component, to give iron arsenate which remains fixed in the cinders.

TABLE II—Economic Comparison of the Processes of Roasting Pyrites. Cost in Ptas/Ton of Useful Pyrite Roasted

Raw Material: Arsenical pyrites.
As 0.5%, Cu 0.8%, basis 46% S.

Plan capacity: 160 tons/day
Working days: 330 in the year
Plant location: Spanish coast

Roasted with	Multi-hearth furnaces		Fluidised-bed furnaces	"P.E." Fluidised-bed furnaces	
	Without heat recovery	With heat recovery	One stage	Model 2	Model 22
Unit capacity tons/day	40	40	80	80	80
Total cost of plant: ptas. × 10^6 [1]	36.5	48	34	36	41.7
COSTS, PTAS.					
Useful pyrite	510.00	510.00	510.00	510.00	510.00
Unprofitable pyrites	40.80	40.80	20.40	20.40	40.80
Operating costs	110.70	110.70	109.20	119.00	141.60
Capital costs	165.90	218.20	154.50	163.60	189.50
Total ptas.	827.40	879.70	794.10	813.00	881.90
CREDITS, PTAS.					
Steam	—	64.00	104.00	96.00	96.00
Cinders [2]	239.20	239.20	—	210.00	318.65
Total ptas.	239.20	303.20	104.00	306.60	414.65
Cost of equal quantity SO_2, ptas.	588.20	576.50	690.10	506.40	467.25
Comparison Ptas./ton of pyrite roasted	Loss −11.70	Basis =	Loss −113.60	Gain +70.10	Gain +109.25

[1] The capital expenditure represents the total cost of the corresponding roasting plants with furnaces, boilers (except in the case of heart furnaces without heat recovery) and electro-filters and includes buildings, transport, installations, storage of pyrites and cinders on the plant site, platforms, ladders, distribution of electric power, etc.
[2] The cinders are valued—when they are used in the iron and steel industry—for their iron and copper content.

PRINCIPAL FUNCTIONAL CHARACTERISTICS OF THE FURNACES USED FOR THE ROASTING OF PYRITES

Types of furnace	Capital outlay for a given roasting capacity[1]	Suitability of cinders for the iron and steel industries	Arsenic removal	Sulphation	Concentration of the sulphurous gases	Heat recovery (tons of steam/ tons of pyrites)
Multi-hearth Without heat recovery	76	Good	Good	Deficient	7–8%	0
Multi-hearth With heat recovery	100	Good	Good	Deficient	7–8%	0.8
Rotating	75	Good	Passable	Very Deficient	8–9%	0
Nichols (flash)[2]	90	None	None	None	14%	1.5
Fluidised Bed (a) One stage	71	None	None	Very Deficient	min. 12%	1.3
(b) Two stage (b—1) 2° Total	75	Passable	Passable	Deficient	min. 12%	min. 1.2[3]
(b—2) 2° Sulphating	83	Good	Good	Good	min. 12%	min. 1.2[3]

[1] 100 is taken as the basis of the necessary capital outlay for a given roasting capacity (calculations are based on 160 tons of pyrites/day) in an installation of hearth furnaces with heat recovery boilers.
[2] Floated pyrites are required; if these are not available, an expensive mineral grinding plant would be necessary, which is not allowed for here.
[3] Minimum guaranteed limits.

In the process, therefore, two-stage roasting is envisaged as in the German and U.S.A. methods. If desired, the atmosphere in the first stage can be oxidising so long as the contact time of the pyrite does not give rise to the formation of ferric iron, but it should be long enough for the distillation of the arsenic sulphide which is practically instantaneous. In the second stage, the solid from the first stage is completely oxidised to the ferric state; simultaneously, the gases are produced which carry away, as oxide or sulphide, the arsenic contained in the pyrite.

A thorough study of the physical chemistry of the process of elimination of arsenic during roasting has made it possible to obtain all the conditions mentioned above. The joint elimination of the arsenic and lead is due to the fact that they are removed in the inert gases as sulphides linked with the removal of the labile sulphur and the formation of ferrous sulphide (pyrrhotite). The last traces of these elements can be removed provided that the contact time is sufficient. However, by the addition of certain catalysts, the contact time can be reduced with the economic advantage that this permits the use of a smaller furnace for the same output. From experience it is found that the catalytic action is promoted by the salts and oxides of manganese, pure or mixed with magnesium salts.

Furthermore, it is not difficult to extract the copper and zinc present in the cinders by direct leaching. To achieve this a final roasting stage with recirculated sulphur dioxide and excess oxygen is used; this controls the temperature, for promoting the formation of the sulphates of copper and zinc, whilst iron is stable as ferric oxide which is insoluble. The cinders so obtained are leached and an excellent recovery of copper is achieved without having to reroast with sodium chloride (chloridising roast); this reduces the cost of leaching by something more than 100 ptas/ton of cinders, which means an extra gain of about 70 ptas/ton of pyrite roasted.

Types of Furnace

A number of furnaces has been developed using the fluidised-bed technique, differing according to the raw material and the objectives sought in roasting. The best design is Furnace Model 22.[3] This furnace is designed for the roasting of iron or cupriferous pyrites containing arsenic and lead, so common in Spanish pyrites; it permits the production of cinders free of arsenic and lead with the metals copper and zinc in a soluble state. The general arrangement is shown in Fig. 1. It consists of two sections each having a superimposed bed. This gives minimum loss of charge and maximum functional elasticity. Bed 1 is fed through *P*, and is fluidised by the gases preheated in lower bed 4 which raise its temperature up to 650°C and in which at least half the sulphur content of the mineral (labile sulphur) is oxidised. The solids then pass through the openings in the dividing wall to the second compartment, bed 2, which is fluidised by the very hot gases coming from the lower bed 3 where the temperature is raised to 840-850°C with a substantial elimination of arsenic and lead carried away in the gases. The solids (pyrrhotite) overflow to bed 3 fluidised by fresh air and recirculated sulphur dioxide introduced through F controlling the combustion of nearly all the sulphur present as sulphide. The cinders pass through the openings in the dividing wall to bed 4, in which sulphating conditions prevail, due to its being fluidised by a mixture of air and sulphur dioxide gases in the right proportions. This bed 4 also preheats the air which feeds bed 1 and permits a final removal of the sulphur remaining as sulphide in bed 3.

For greater simplicity, the solid flow has been shown by straight lines and the gas flow by dotted lines. The feed *D* is fitted to introduce the accelerators for the removal of arsenic, and feed *H* is fitted, in case it is required, for the addition of the appropriate material to increase the solubility of the copper and zinc.

Furnace Model 21

This furnace has been modified to roast pyrites with a low content of non-ferrous metals (in particular, copper) where a sulphating stage is not necessary, or because the cinders are to be chloridised. With this furnace the arsenic is eliminated to less than 0.02% and lead to ~0.25%. Its chief use is for the roasting of arsenical iron pyrites containing lead—a typical case for minerals of Spanish origin.

Furnace Model 2

Very often, the elimination of lead to such a high degree is not necessary, when the cinders are used in the iron and steel industry. Thus the furnace can be even simpler as in Model 2, which can be used for the elimination of arsenic (As $>0.07\%$). It consists (see Fig. 2) of only two adjacent communicating beds; in 1 a temperature of 740-750°C is obtained by controlled combustion. By this means, the removal of arsenic is very good and the mineral, in which pyrrhotite predominates, passes over to bed 2, where the combustion of nearly all the sulphur present takes place with excess air at temperatures of about 900°C. The heat given off in this bed 2 is recovered in the form of steam. Some of the lead remains in the cinders, in an amount higher than is required in the iron and steel industry, at least in the case of Spanish ores being treated. The cinders obtained have very similar analytical characteristics to those from multi-hearth furnaces.

There is a variation of this furnace (Model 2) with beds

1 and 2 superimposed. This is very practical, as it gives a better heat recovery when the mineral is screened between narrow limits to give a homogeneous product, but otherwise the characteristics are analogous to those of Model 2.

Flow Sheets

The flow diagrams (Figs. 1 and 2) show the roasting of Spanish pyrites containing 46.2% S, 42.6% Fe, 0.8% Cu, 2.2% Zn, 1.2% Pb, 0.5% As and 6.5% inerts. The intermediate de-arsenication and de-lead processes alone taking place in beds 1 and 2 (Fig. 1) or the de-arsenication process alone taking place in bed 1 (Fig. 2) may be studied in the flow-sheets by the analysis of the intermediate products.

The thermal conditions in the several stages are shown in both cases, as well as the inlet gaseous volume, the concentration of SO_2 in the roasting gases, and the degree of heat recovery, which is slightly lower when only de-arsenicating roasting taking place, and is roughly 1.4 tons of steam/ton of burnt pyrites, in all cases.

Economy Achieved in the "Piritas Españolas" Process

The process solves the important problem of being able to produce cinders suitable for the iron and steel industry and this, in particular, applies to the Spanish pyrites containing arsenic and lead.

This process can compete with the most modern methods of roasting pyrites now in use, e.g., multi-hearth furnaces with heat recovery. With cupriferous pyrites the economic results are even more favourable. In the tables (I and II) the detailed cost of roasting pyrites are shown, based on an installation using 160 tons per day and working 330 days a year in factories placed by the coast, in Great Britain and in Spain.

As the original pyrites contain lead, whose recovery would be wholly uneconomical by a hydrometallurgical process, but which must be eliminated if the full benefit is to be obtained from the cinders for the iron and steel industry, the advantage of the "Piritas Españolas" process is outstanding.

REFERENCES

[1] Vian Ortuño. A. "Problemática de la pirita española en el momento presente" Conference of May 14, 1959, published in *An. Soc. Esp. Fis. y Quim.*, 6, 533, June 1959.

[2] Spanish Pat. 208,449, 212,897, 235,440 (March 24, 1953); D.R.P. 1,015,399; U.S. Pat. 2,847,281; British Pat. 755,259; granted in other countries to Instituto Nacional de Industria (Madrid).

[3] Spanish Pat. 234,996 (April 23, 1957); French Pat. 1,202,993; applied for in other countries.

Metering Pumps Increase Production

Their characteristics make them essential for many chemical processes

METERING pumps are being increasingly used in the chemical industry. One well-known manufacturing chemist in their Stockport plant have used a Metripump for one particular application most successfully. Use of this Metripump, one of the G type, has resulted in an improved and more compact layout, increased production and simplified mode of operation. Plant supervision has been reduced and the possibility of human error in the control of the additives practically eliminated.

The plant installed was required to carry out a reaction involving the simultaneous addition of two major raw materials in a fixed ratio, over a period of about 5 hr. The two materials could not be mixed before they entered the reaction vessel. On the experimental production unit this was achieved by breaking the additives down into separate distinct parts. Small measuring tanks, fitted between the storage tanks and the reaction vessel, were filled automatically by the use of float switches and magnetic valves. The total contents of the measuring vessels were then added to the reaction vessel via needle control valves. Thus, at the end of each distinct addition, the correct quantities of the raw materials had been added despite possible variations in rate during the addition. This system, although used for about two years, was complex and the needle and magnetic valves and the float switches required considerable attention.

A larger plant was designed to replace the experimental set-up, and ways were sought of improving the method of additions. On the new plant the measuring tanks, magnetic valves and the float switches have been replaced by one duplex metering pump which gives a continuous feed of the two raw materials in a constant fixed ratio although the overall rate of addition is infinitely variable. This system has now been running for three months and the metering pump has handled about 40,000 gal. of the raw materials successfully.

Continuous Soap Process

A further application of the use of Metripump equipment is at the Thomas Hedley research laboratories at Longbenton. Here metering pumps are used in a continuous soap process pilot plant which supplies small quantities of various qualities of soap for research and development. This plant provides a quick method of producing soap in a controlled quantity to specific formulations. It is simply a rotary Shear plate mixer into which are fed, at controlled rates, fatty acid and caustic.

The fatty acid and caustic are each stored in separate tanks from which they are pumped by metering pumps into the mixing chamber of the Shear plate mixer. The mixed liquids are discharged from the mixer into a storage vessel, provision being made for recirculation. The controlling factor of the mixing operation is the alkalinity of the finished product measured as a *p*H value and termed the end of point of the reaction.

The use of metering pumps in this operation enables production of various qualities of finished product from the same raw materials by varying the pumping rate and therefore the delivery of each material, under strictly controlled conditions. The pumps also permit the use of varying grades of raw materials, since the rate capacity of the pump is infinitely variable and can be adjusted while running. This ability to alter the rate of pumping whilst in operation also enables a critical control to be exercised over the *p*H value of the finished product. In general, simplification of operation is obtained. The use of metering pumps avoids the constant attention of operators and the installations of complicated flow measuring instruments.

A wide range of pump heads is available and many variations of output and working pressures are possible ranging from 0.3 gph at 5 psi to 7.5 gph at 200 psi. These varied characteristics make this type of equipment most essential in laboratory research and development work and for pilot-plant manufacturing operations.

Metering Pumps Ltd., manufacturers of the Metripump, also offer a complete technical service on the use of their equipment, and have recently introduced a plant hire service which now makes metering pumps available for short-term experimental work and trials.

PRESSURE DROP, LOADING AND FLOODING IN IRRIGATED PACKED TOWERS

The author reviews the available correlations and proposes an improved correlation to cover different gases and liquids

by H. E. EDULJEE, Ph.D., A.M.I.Chem.E.

PACKED towers are widely used in the chemical industry for operations which require contact between liquid and gas (or vapour) in counter-current flow. Data on pressure drop, loading and flooding are required for the design of such columns. Sherwood, Shipley and Holloway[1] were the first to attempt a correlation of the flooding data. Later, Lobo *et al.*[2] improved the Sherwood correlation by adjusting the values of the packing constant to get a better fit with experimental data. Bertetti,[3] Sakiadis and Johnson[4] and Lerner and Grove[5] have derived semi-theoretical equations to correlate flooding data.

Loading data have been correlated by Garner and Ellis[6] and Otake and Kimura[7] by dimensional analysis. Attempts to correlate the entire régime from below the loading point to the flooding point have been made by Zenz[8] and Leva.[9] Zenz has derived equations by analogy to flow through orifices; the treatment is interesting, but the method is too cumbersome for everyday use. Leva has prepared generalised plots based on the Sherwood *et al.* correlation. These plots are convenient to use; their disadvantages will be discussed later.

The brief review of existing correlations shows that Leva's correlation[9] is the only one that is reasonably satisfactory, and showed a possibility of improvement. The Otake-Kimura[7] correlation for loading data appeared to have none of the disadvantages of the Sherwood correlation for flooding data, and it was felt that if the Otake-Kimura correlation could be combined with the Leva method of plotting, then a satisfactory correlation of the entire flow régime would be obtained.

Counter-current Gas-liquid Flow through Packed Towers

When liquid at constant rate flows down a column and gas is passed up the column, and the pressure drop for the gas is plotted against the gas rate, then a curve such as AA′ in Fig. 1 is obtained. Such curves were first published by Mach[10] and White.[11] The curve can be divided into three segments: (a) the segment AL which, for low to medium liquid rates, has a slope of 1.8 to 2.0; (b) at a point L the slope increases to 3.3 to 4 for the segment LF; (c) at F the slope becomes practically infinite. At high liquid rates, the curve is like BB′ in Fig. 1. The segment BL has a slope much less than 1.8 to 2.0. The data of Mach[10] and White[11] suggested that the slopes changed sharply at point L and F and White called these points the "loading" and "flooding" points respectively.

Symbols Used

C_1, C_2 = packing factors;
F = packing voids, cu. ft/cu. ft bed;
G = gas mass rate, lb./hr sq. ft;
L = liquid mass rate, lb./hr sq. ft;
$\triangle p$ = pressure drop, in. water/ft packing;
S = packing surface, sq. ft/cu. ft;
V_G = gas velocity, ft/sec.;
V_L = liquid velocity, ft/sec.;
μ = liquid viscosity, cp;
ρ_G, ρ_L = density of gas and liquid, lb./cu. ft; and
δ = nominal dimension of packing, in.

Observation of the column does not show any change in the character of the gas or liquid flow as the loading point is approached and passed. The flooding point, however, is usually accompanied by build-up of the liquid over the top of the bed, excessive entrainment, etc. Some investigators have preferred to locate the flooding point by observing some such change in flow conditions, rather than graphically as in Fig. 1. The "visual" flooding point, however, depends on the criterion of flooding chosen by the investigator, while the "graphical" flooding point is more objective. In this work, only graphical flooding points have been used; where "visual" flooding points have been reported, the graphical points have been obtained from the published curves or by replotting the original data.

The opinion has been expressed[5, 8, 12] that the plots AA′ and BB′ in Fig. 1 do not consist of three straight-line segments, but that the slope increases continuously from point L to F. Zenz[8] has defined point F as the point where the slope becomes infinity. Elgin and Weiss[12] suggest that Mach and White obtained a sharp break at point L because their data was taken at widely spaced intervals of G; if the intervals had been smaller, the plot AA′ would have appeared as a continuous curve, the portion AL being linear and the slope then increasing continuously from L to F. According to this view, there is a "loading zone" rather than a loading point. Whether "zone" or "point", the loading region is important from the mass transfer point of view[13] and some attempt must be made to locate it precisely.

Dr. Eduljee *is with National Peroxide Ltd., Sewri X Road, Bombay-31, India.*

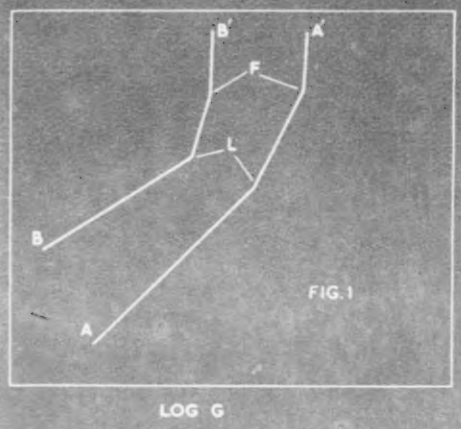


FIG. 1

Fig. 1 Typical pressure-drop, gas rate curves for irrigated packed beds.

Fig. 2. Plot of loading data for air-water system for Raschig rings, according to Equation (1).

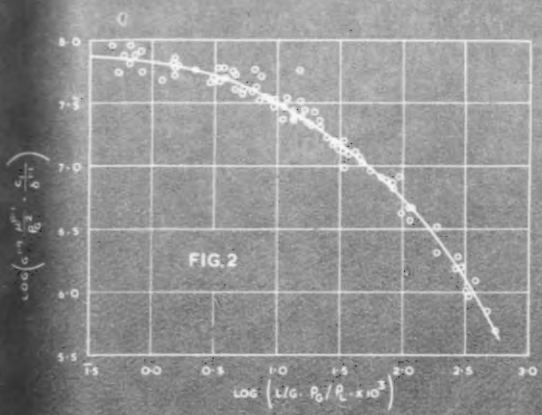
Fig. 2(a). Plot of loading data for air-water system for Berl saddles according to Equation (1). *The curve is the same as the one drawn in Fig.* 2.

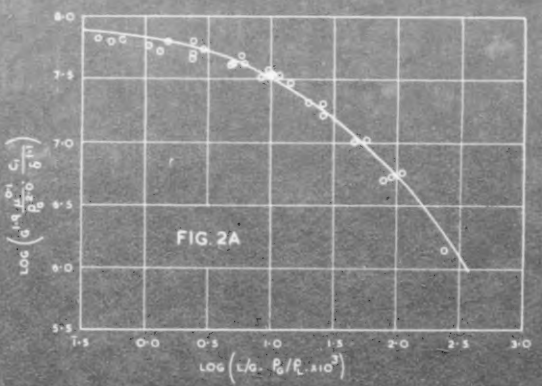
Fig. 3. Plot of flooding data for Raschig rings and Berl saddles for air-water system.

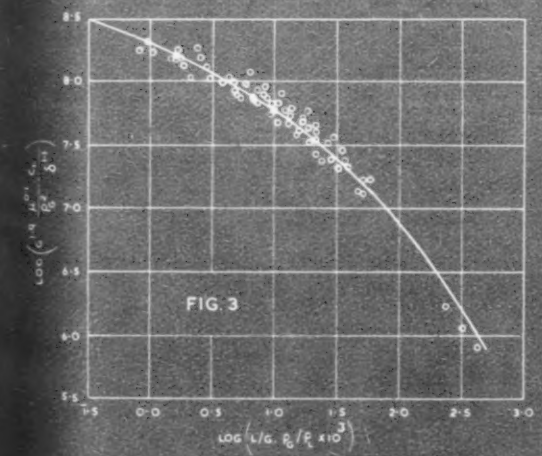
Fig. 4. Plot of flooding data for systems other than air-water for Raschig rings and Berl saddles. The curve is the same as the one shown in Fig. 3.

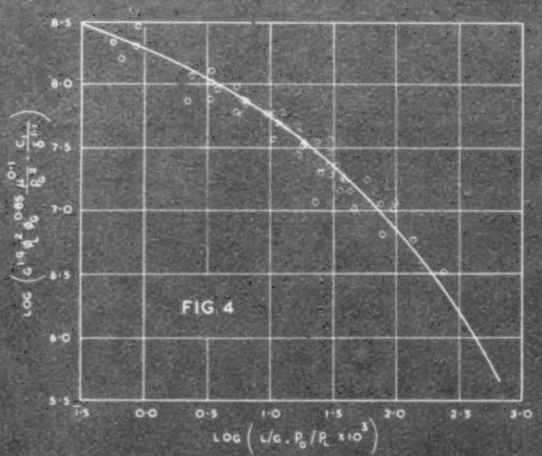
Fig. 5. Correlation of data for 0.1, 0.4 *and* 0.1 *in. water/ft isobars.*

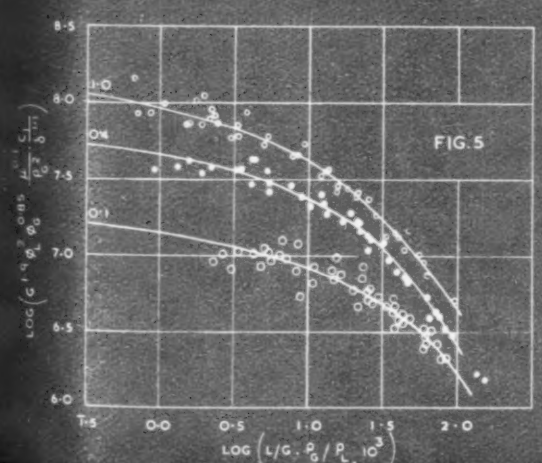
Fig. 6. General correlation in terms of gas rate from 0.1 *in. water isobar to flooding. The loading curve has been omitted so as not to confuse the figure. The co-ordinates of the plot are given in Table II*

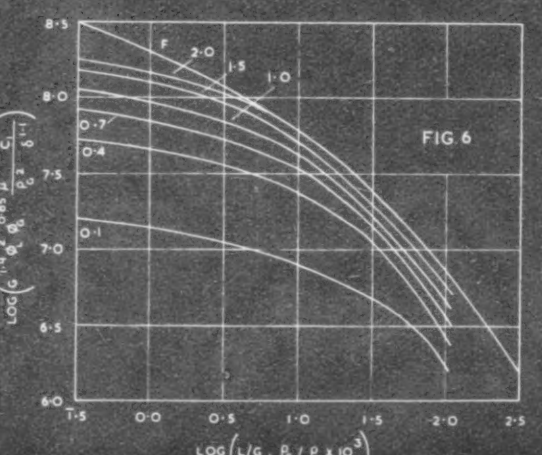












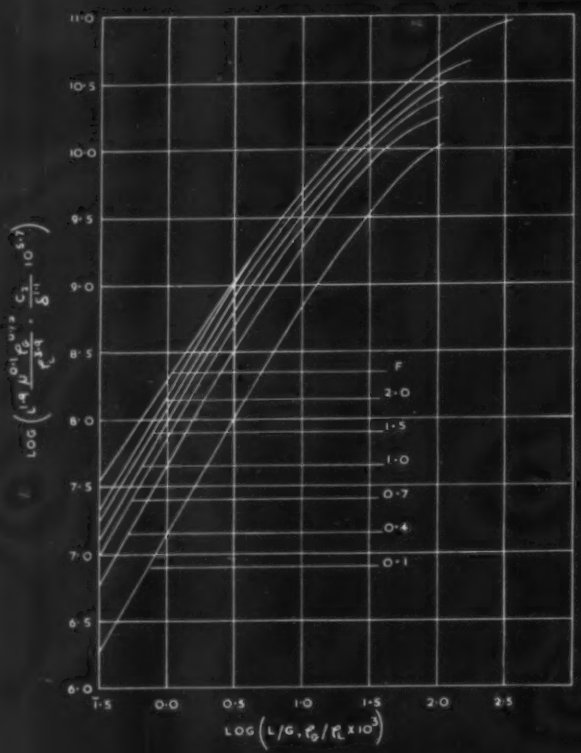


Fig. 7. General correlation in terms of *liquid* rate from 0.1 in. water isobar to flooding.

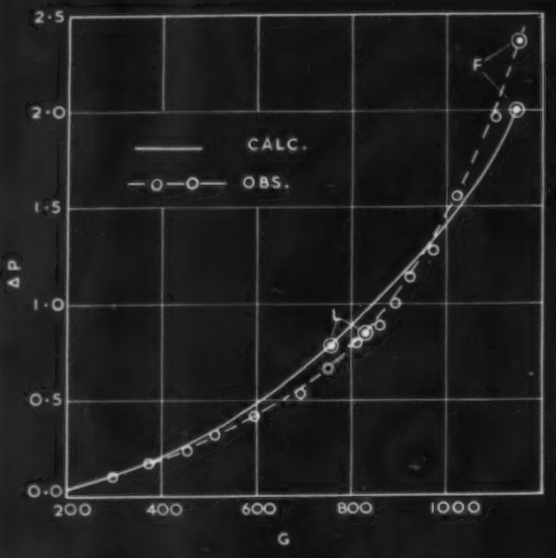


Fig. 8. Comparison between calculated and observed values for the sample calculation.

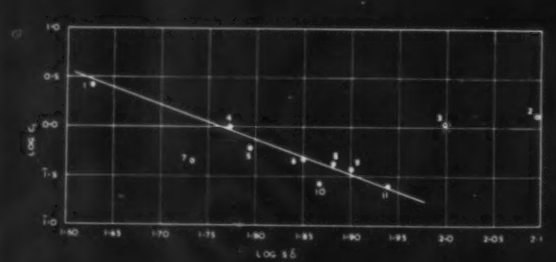


Fig. 9. Relationship between the packing constant and the properties of the packing. The numbers against the points identify the packings in Table I.

In this work the loading point is defined as the point where the slope of the lower, linear portion of the curves AA′ and BB′ (Fig. 1) begins to increase. This point can be located more easily by plotting[14] log $(\triangle P/G^2)$ against log G; the lower, linear portion then becomes a practically horizontal line (or has a negative slope) and the change of slope at point L shows up more sharply.

Correlation of Loading and Flooding Data for Air-water System

The Otake-Kimura[7] correlation for loading data can be written in general form as:

$$\frac{V^2_G}{2\,g\,\delta}\left(\frac{\delta\,L}{\mu}\right)^n C = f\left(\frac{V_G}{V_L}\right)$$

Ignoring $2g$, converting linear velocities to mass rates, and rearranging, gives:

$$G^{2+n} \cdot \frac{\mu^{-n}}{\rho_G{}^2} \cdot \delta^{n-1}\, C_1 = f'\left(\frac{L}{G} \cdot \frac{\rho_G}{\rho_L}\right)$$

For a particular packing C_1 will be constant, and for a particular gas-liquid system α_G, α_L and μ will be constant. Hence, plotting log G_L against log δ at constant value of $(L/G \,.\, \alpha_G/\alpha_L)$ will allow n to be calculated. Such plots were made from loading data for Raschig rings[11, 15, 16, 17, 18] for δ ranging from $\frac{1}{8}$ in. to 2.0 in. and for Berl saddles[15, 16] for δ ranging from 0.5 to 1.5 in. for values of log $(L/G \,.\, \alpha_G/\alpha_L \,.\, 10^3) = 1.0$ and 1.5 for the air-water system. The value for n so obtained was -0.1, and the correlating equation then becomes

$$G^{1.9} \cdot \frac{\mu^{0.1}}{\rho_G{}^2} \cdot \frac{C_1}{\delta^{1.1}} = f'\left(\frac{L}{G} \cdot \frac{\rho_G}{\rho_L}\right) \qquad \ldots . (1)$$

The fact that two different packings gave the same value of n suggests that the term $\delta^{1.1}$ will adequately allow for the effect of packing size for all types of packing.

Fig. 2 is a plot of the loading data for Raschig rings for the air-water system[11, 15–18] according to Equation (1), the value of C_1 being arbitrarily taken as 1.0. As n is the same for Berl saddles as for Raschig rings, a similar plot for Berl saddles would give a curve parallel to that for Raschig rings. If the curve for Raschig rings is taken as standard, then the value of C_1 for Berl saddles can be adjusted to make its curve coincide with the standard curve. All loading data for Berl saddles[15, 16] were analysed in this way and the value $C_1 = 0.4710$ was obtained. Points for Berl saddles with this value of C_1 are shown in Fig. 2a.

Packing factors C_1 were calculated in a similar manner for stacked Raschig rings[16, 18] and for dumped and stacked 3-in. single spiral tiles.[16] Values of C_1 are listed in Table I.

The Sherwood[1] correlation for flooding does not adequately represent loading data[9]; it was decided to see if the Otake-Kimura correlation for loading data—Equation (1)—could represent flooding data. In Fig. 3, flooding data[15, 17, 19–21] for Raschig rings and Berl saddles for the air-water system have been plotted according to Equation (1), using the same values for C_1 as for the loading plot. The correlation is satisfactory.

Effect of Gas and Liquid Properties

Figs. 2 and 3 have tested Equation (1) with respect to the properties of the packing only; the effect of fluid properties must now be studied. Lubin[15] has obtained flooding data for several sizes of Raschig ring and Berl saddle with air as the gas and water and water-glycerol mixture as liquid. The data were grouped according to liquid densities and each group plotted according to Fig. 2; each group fell on separate lines which could be brought together by multiplying the ordinate by φ^2_L where $\varphi_L = (\rho_{H2O}/\rho_{Liq.})$. This is the same correction term used by Leva[9] to improve the

Sherwood correlation. As the data could be correlated after correcting for density only, the viscosity term in Equation (1) obviously accounts satisfactorily for this property. This was confirmed by plotting the flooding data of Bain and Hougen[22] and Schoenborn and Dougherty[21] who worked with air and various oils. The range of viscosities covered was 0.8 to 31 cp and of density 55 lb/cu. ft to 72 lb/cu. ft.

The data of Bain and Hougen[22] was used to study the effect of gas properties. They give flooding data for various oils with air, carbon dioxide and hydrogen. It was found that the data for the different gases could be brought together by multiplying the ordinate of Fig. 3 by $\varphi_G^{0.85}$ where φ_G is equal to (ρ_{gas}/ρ_{air}). The final correlating equation is then:

$$\log\left[G^{1.9}\frac{\mu^{0.1}}{\rho_G{}^2}\cdot\varphi_L{}^2\cdot\varphi_G{}^{0.85}\cdot\frac{C_1}{\delta^{1.1}}\right]=f\left[\log\left(\frac{L}{G}\cdot\frac{\rho_G}{\rho_L}\cdot 10^3\right)\right] \quad \ldots.(2)$$

The plot of flooding data for systems other than air-water is shown in Fig. 4.

The equation was tested, and found satisfactory for loading data, using the results of Lubin[15] and Bain and Hougen.[22]

Substituting the values $\rho_{H2O}=62.3$ and $\rho_{air}=0.74$, Equation (2) can be written as

$$\log\left[G^{1.9}\frac{\mu^{0.1}}{\rho_G{}^{1.15}\,\rho_L{}^2}\cdot\frac{C_2}{\delta^{1.1}}\right]=f\left[\log\left(\frac{L}{G}\cdot\frac{\rho_G}{\rho_L}\cdot 10^3\right)\right]\ldots.(3)$$

$$\text{where } \log C_2=\log C_1+4.5602 \quad \ldots.(4)$$

The co-ordinates of the loading and flooding curves are given in Table II.

Isobaric Correlation

For most packings, the pressure drop at flooding is 2-3 in. water/ft packing. Leva[9] argued that this is practically an isobaric condition and suggested that an equation that satisfactorily correlated flooding data should also correlate gas and liquid rates at other constant pressure drops below the flooding point. He showed that the Sherwood correlation gave a satisfactory plot up to pressure drops as low as 0.1 in. water/ft packing, although it failed to correlate loading data. It has been shown that Equation (3) correlates both flooding and loading data and it was then tested for other portions of the $\triangle P$-L-G curves (Fig. 1).

Fig. 5 shows the correlation for 0.1, 0.4 and 1.0 in. water/ft packing isobars. The gas is air in every case, but a wide variety of packings, sizes and liquids is shown in Fig. 5. The successful correlation in Fig. 5 shows that the packing characteristic C_1 can be obtained from pressure drop data below the flooding or loading points; this method was in fact used to obtain C_1 values for Intalox saddles,[23] metal Raschig rings[24] metal Pall rings[24] and Tellerette packing.[27]

Fig. 6 shows a plot of the final correlation over the whole régime from a pressue drop of 0.1 in. water/ft packing up to the flooding point. The co-ordinates of the plot are given in Table II. It will be seen that the pressure drop at flooding at low liquid rates is above 3.0 in. water, but drops to a practically constant value of 2.0 at high liquid rates. The pressure drop at loading is about 0.7 in. water at low liquid rates and rises to over 1.0 in. at high liquid rates.

Accuracy of Correlation

The accuracy of the correlation was checked by calculating G for the reported values of $(L/G\,.\,\rho_G/\rho_L)$ and comparing with the measured G. This method was preferred to that of calculating G for reported values of L, because in the type of operations for which packed towers are used, e.g., distillation, absorption, the reflux ratio L/G is more important than G itself. The comparison is shown in Table III.

A more stringent test is shown in Table IV. David[25, 26] has carried out distillation runs with various binary mixtures at total reflux in a column packed with metal Raschig rings; he measured the pressure drop at various vapour rates and has reported flooding data for several of the runs. The calculated vapour rates are compared with the reported values in Table IV. Considering the uncertainty in the values of the physical properties of the mixtures at the boiling points, and also the fact that the properties vary from top to bottom of the tower, the agreement between calculated and reported values is satisfactory.

Sample Calculations

Air and water are flowing counter-currently in a tower packed with 1-in. Berl saddles. It is proposed to use a water rate of $L = 9965$ lb/hr sq. ft. The temperature is 70°F. Calculate the pressure drop-gas rate curve, from 0.1 in. water/ft packing, up to the flooding point.

The solution of this problem with the help of Fig. 6 is a tedious trial-and-error process. L is known; a value for G is assumed and the abscissa calculated; the ordinate value is then read for an isobar, say 0.1 in. water, and G calculated and compared with the assumed value. This process of trial-and-error calculation must be repeated for every isobar and for the loading and flooding curves. A direct solution can be obtained thus.

For a particular isobar, at the *correct* value of G, let

$$\log\left[\frac{L}{G}\cdot\frac{\rho_G}{\rho_L}\cdot 10^3\right]=x \quad \ldots.(5)$$

$$\text{and } \log\left[G^{1.9}\frac{\mu^{0.1}}{\rho_G{}^{1.5}\,\rho_L{}^2}\cdot\frac{C_2}{\delta^{1.1}}\right]=y \quad \ldots.(6)$$

Eliminating G between Equations (5) and (6) gives:

$$\log\left[L^{1.9}\cdot\frac{\mu^{0.1}\,\rho_G{}^{0.75}}{\rho_L{}^{3.9}}\cdot\frac{C_2}{\delta^{1.1}}\cdot 10^{5.7}\right]=y+1.9\,x \quad \ldots.(7)$$

In Equation (7) all the terms on the left-hand side are known and are constant for the problem; hence, $(y + 1.9\,x)$ will be constant for all isobars and for the flooding and loading curves. Fig. 7 shows a general plot of

$$y+1.9\,x=\log\left[L^{1.9}\frac{\mu^{0.1}\,\rho_G{}^{0.75}}{\rho_L{}^{3.9}}\cdot\frac{C_2}{\delta^{1.1}}\cdot 10^{5.7}\right]$$

$$\text{against } \log\left[\frac{L}{G}\cdot\frac{\rho_G}{\rho_L}\cdot 10^3\right]$$

which can be easily constructed from the data given in Table II.

For the problem:

	$1.9 \log L$	$= 7.59711$
	$0.75 \log \rho_G$	$= -0.84807$
	$0.10 \log \mu$	$= -0.00083$
	$3.9 \log \rho_L$	$= 6.99988$
	$\log C_2$	$= 4.2332$
	$1.1 \log \delta$	$= 0.0$
and	$y + 1.9\,x$	$= 9.68153$

For this value of the ordinate, for the 0.1 isobar, the abscissa is 1.62; substituting the known values of L, ρ_G and ρ_L gives $G = 280.3$ lb. of air/hr sq. ft. Values of G for other pressure drops are calculated similarly and given in Table V. Fig. 8 compares the calculated curve with the results of Lubin[15] for these conditions.

Fig. 7 is complementary to Fig. 6. In one case the ordinate is in terms of gas rate; in the other case, the ordinate is in terms of liquid rate.

TABLE I—Packing Factors to be Used With the Correlations

Packing No.	Packing	Nominal size studied (in.)	C_1	Remarks
1	Broken solids	0.6 to 1.4	2.7517	Isobaric, loading
2	Spiral tiles (stacked)	3 in. only	1.331	Loading only
3	Spiral tiles (dumped)	3 in. only	1.105	Loading only
4	Raschig rings (dumped)	½ to 2.0	1.000	Isobaric, loading, flooding
5	Metal Raschig rings	1.0 to 2.0	0.6104	Isobaric, loading
6	Berl saddles	0.5 to 1.5	0.4710	Isobaric, loading, flooding
7	Wire helices	0.5 only	0.4472	Loading, flooding
8	Tellerette	1.0 only	0.4184	Isobaric, flooding
9	Intalox	0.5 to 1.5	0.3698	Isobaric only
10	Metal Pall rings	1.0and1.5	0.2611	Isobaric only
11	Raschig rings (stacked)	0.6 to 1.5	0.2512	Isobaric and loading

(The "Remarks" column gives the type of data from which the packing factors were calculated)

TABLE II—Co-ordinate of the Final Correlation (Fig. 6)

x	y							
	0.1	0.4	0.7	Loading	1.0	1.5	2.0	Flooding
−1.5	7.21	7.725	7.930	7.90	8.05	8.175	8.252	8.49
0.0	7.15	7.652	7.85	7.84	7.955	8.09	8.16	8.29
0.5	7.05	7.55	7.725	7.73	7.84	7.955	8.025	8.075
1.0	6.915	7.365	7.515	7.55	7.615	7.705	7.775	7.75
1.5	6.675	7.05	7.15	7.18	7.225	7.3	7.375	7.375
1.75	6.515	6.78	6.9	6.96	6.95	7.04	7.14	7.14
2.0	6.225	6.44	6.555	6.73	6.67	6.75	6.87	6.87
2.5	—	—	—	6.075	—	—	—	6.20

$$x = \log\left[\frac{L}{G}\cdot\frac{\rho_V}{\rho_L}\cdot 10^3\right]$$

$$y = \log\left[G^{1.9}\,\frac{\mu^{0.1}}{\rho_G^{1.15}\,\rho_L^{0.3}}\cdot\frac{C_2}{\delta^{1.1}}\right]$$

0.1, 0.4 . . . isobars, ins. water/ft. packing.

TABLE III—Deviation of Calculated Values of G from Reported Values

Range of % dev.	Loading		Flooding		Isobaric		All points	
	No. of points	% of total	No. of points	% of total	No. of points	% of total	No. of points	% of total
0 to 5.0	68	41.21	70	34.60	272	47.70	410	43.56
5.1 to 10.0	62	37.56	68	33.70	179	31.40	309	32.91
10.1 to 15.0	22	13.33	25	12.38	56	9.98	103	10.97
15.1 to 20.0	7	4.25	25	12.38	39	6.01	71	7.56
> 20.1	6	3.65	14	6.94	27	4.91	47	5.00
Totals	165		202		573		940	

TABLE IV—Comparison of David's[26] Flooding Points from Distillation Runs with Calculated Values

System	Pressure mm Hg.	Gp		% deviation
		observed	calculated	
Benzene-toluene	760	1015	793	21.9
	500	883	712	19.4
	250	672	615	8.5
	100	502	425	15.3
Benzene-ethylene chloride	760	1077	1340	23.6
	760	919	1055	14.8
	400	811	1096	35.2
	400	723	886	22.6
	100	544	610	12.1
	100	444	547	23.2
Ethanol-water	760	749	606	19.1
	250	603	530	12.1
	100	457	417	8.7
			average =	18.2

TABLE V—Solution of Sample Calculation

Δp	x	G (calculated)
0.1	1.62	280
0.4	1.322	557
0.7	1.21	721
L	1.19	755
1.0	1.143	837
1.5	1.055	1030
2.0	1.01	1142
F	1.01	1142
$x = \log\left[\frac{L}{G}\cdot\frac{\rho_V}{\rho_L}\cdot 10^3\right]$		
L = Loading		
F = Flooding		

The Packing Factors

The packing factor C_1 in Equation (2) is a dimensionless quantity, as can be seen from the original Otake-Kimura equation. The value of C_1 is specific for a packing and is independent of the nominal size of the packing; small values of C_1 signify low resistance on the part of the packing to fluid flow. If C_1 is to be related to the packing, then it must be some function of the properties of the packing; S, F and δ. The C_1-values given in Table I were obtained empirically: a value of $C_1 = 1.0$ was arbitrarily given to Raschig rings and the C_1 values for other packings adjusted to make their data fall on the curve for Raschig rings. We must now see if any connection can be found between C_1 and S, F and δ.

The Sherwood correlation gives the packing factor as S/F^3. Apparently one can calculate the packing factor if S and F are known for a particular packing. In practice this is not so; F for the same packing will vary according to the method of preparing the bed, and as F appears raised to the third power even small differences in F will be exaggerated. Also, for the same packing, S will be larger for smaller values of F and this will aggravate the differences in S/F^3 obtained by different authors. Lobo *et al.*[2] have given empirical values for S/F^3 for use with the Sherwood correlation; although the term S/F^3 has been retained, Lobo's values actually bear little relation to it. A major disadvantage of the packing factor in Sherwood's correlation is that it varies with nominal size of the packing.

The packing factor C_1 must be some function of S, F and δ which is dimensionless and also does not vary with δ. The simplest relation would be $C_1 = \text{const.}/F$; for a particular packing F is, in fact, remarkably constant for different values of δ. Unfortunately, the inverse proportionality between C_1 and F is not observed; Berl saddles have C_1 and F values which are *both* smaller than those for Raschig rings.

Otake and Kimura[7] have correlated C_1 with $S\delta$ which is also very constant for a packing. A plot of $\log C_1$ against $\log S\delta$ is shown in Fig. 9 for all the packings listed in Table I. With the exception of three packings, the others correlate reasonably well to give the equations:

$$\log C_1 = 5.9338 - 3.354 \log S\delta$$
$$\log C_1 = 10.4940 - 3.353 \log S\delta$$

In the case of the three exceptions, loading or flooding data were available for one size of packing only, and there was no way of independently checking the value of S given by the authors. The advantage of $S\delta$ over S/F^3 is that it does not depend on the method of packing and also it is independent of δ.

REFERENCES

1. Sherwood, Shipley and Holloway. *Ind. Eng. Chem.*, 1938, **30**, 765.
2. Lobo *et al. Trans. Am. Inst. Chem. Eng.*, 1945, **41**, 693.
3. Bertetti. *Trans. Am. Inst. Chem. Eng.*, 1942, **38**, 1023: 1944, **40**, 395.
4. Sakiadis and Johnson. *Ind. Eng. Chem.*, 1954, **46**, 1229.
5. Lener and Grove. *Ind. Eng. Chem.*, 1951, **43**, 216.
6. Garner and Ellis. *J. Appl. Chem.*, 1955, **5**. 105.
7. Otake and Kimura. *Chem. Eng. (Japan)*, 1953, **17**, 261.
8. Zenz. *Chem. Eng. Prog.*, 1947, **43**, 415.
9. Leva. *Chem. Eng. Prog. Sym. Series No. 10*, 1954, **50**, 51.
10. Mach. *Forsch. Gab. Ing.*, 1935, **6**. 375.
11. White. *Trans. Am. Inst. Chem. Eng.*, 1934-5, **31**, 390.
12. Elgin and Weiss. *Ind. Eng. Chem.*, 1939, **31**, 435.
13. Granville. *Brit. Chem. Eng.*, 1957, **2**. 70.
14. Rose and Young. *Proc. Inst. Mech. Eng.*, 1952, **1B**, 114, *vide* discussion of the paper.
15. Lubin. *Ph.D. thesis, Toronto Univ.* (1952).
16. Tilson, cf. Molstad *et al. Trans. Amer. Inst. Chem. Eng.*, 1942, **38**, 387.
17. Winning. *Ph.D. thesis, Toronto Univ.* (1952).
18. Uchida and Fujita. *Soc. Chem. Ind. (Japan)*, 1936, **39B**, 432: 1937, **40B**, 238: 1938, **41B**, 275.
19. McManus. *M.Sc. Thesis, Georgia, Inst. of Tech.* (1952).
20. Sarchet. *Trans. Amer. Inst. Chem. Eng.*, 1942, **38**, 283.
21. Schoenborn and Dougherty. *Trans. Amer. Inst. Chem. Eng.*, 1944, **40**, 51.
22. Bain and Hougen. *Trans. Amer. Inst. Chem. Eng.*, 1944, **40**, 29.
23. U.S. Stoneware Co. *Bulletin S-29-R.*
24. Eckert *et al. Chem. Eng. Prog.*, 1958, **54**, 71.
25. David. *Dechema Monograph No. 23* (1953).
26. Kirschbaum and David. *Chem. Ing. Tech.*, 1953, **25**, 592.
27. Teller and Ford. *Ind. Eng. Chem.*, 1958, **50**, 1201.

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THE CHEMICAL PLANT CONTRACTOR AND THE MANUFACTURER

PART II*

Commissioning, testing and proving of plant and its operation are discussed by the author

by M. DAVIDMANN, B.Sc.

Commissioning, Testing, Proving

BY commissioning is meant work carried out by the contractor's staff in putting the plant into operation, in ensuring that teething troubles are kept to a minimum and in overcoming them. Testing refers to tests carried out by the manufacturer's staff to show that the plant meets the manufacturer's requirements. A guarantee test, at times misleadingly called acceptance test, is carried out when the manufacturer suspects that the contractor is not capable of maintaining his guarantee, or that he has failed to do so, and this we call "proving".

When giving a performance guarantee, the contractor tells the manufacturer what the plant will do and under what circumstances it will do this. The contractor, in the course of commissioning, ensures that the plant operates properly, and satisfies himself that performance is as expected, or better. If performance is worse than expected and does not fulfil the guarantee, a policy decision is made by the contractor; namely, whether corrective action should be taken before the plant is handed over, or whether the manufacturer be asked to accept the plant subject to corrective action before a specified later date. Also the manufacturer may be asked to accept the plant as it stands, the short-comings being pointed out to him. Which of these alternatives is chosen depends not only on the extent of corrective action required but also on how important it is to the manufacturer to start production immediately. The policy decision with subsequent formal approach to the manufacturer is therefore made only after preliminary informal discussions between contractor and manufacturer.

Once the plant has been commissioned and handed over as an operating unit, we may take it, at least as far as the United Kingdom is concerned, that its performance is as guaranteed by the contractor, unless this be proved otherwise by the manufacturer.

The manufacturer cannot start production without operating the plant. Hence as soon as the plant is handed over to the manufacturer, as an operating unit, the plant should be deemed accepted, even should the manufacturer decide not to use the plant until some later date.

Sub-contractors may dispatch a prefabricated unit plant which the contractor mounts on prepared foundations and to which he connects the various process streams and services. As contractors and sub-contractors, during commissioning, prove to themselves that their guarantee has been maintained, their executives are at liberty to decide in any particular case that for the standard plant supplied no check on performance is required. In the case of the sub-contractor's prefabricated unit plant, for example, this implies that it may be deemed accepted on delivery to site. However, the manufacturer or contractor may prove, within a reasonable time from the plant having been handed over or delivered, that the contractor or sub-contractor, respectively, has not maintained his guarantee. This period is usually limited to six months or one year and it is during this period that contractors and sub-contractors generally supply, free of charge, replacement parts proved defective because of faulty workmanship or faulty materials.

It is the manufacturer who tests the plant to find out whether it meets his requirements. The initial process definition given to the contractor may have been inadequate and certain aspects of the process may not have been appreciated earlier on. Hence the manufacturer tests the plant and determines subsequent policy. He may decide to have the plant modified at his expense, to use it as it stands, or to carry out a guarantee test. The manufacturer arranges, and pays for, the supply and disposal of the necessary materials and services, in the quantities and at the rates and purities he requires. These need not be related to the contractor's guarantee, as it is the plant's ability to meet actual requirements that is being tested. For example, the manufacturer may now wish to operate at half the design output, or he may now wish to vary the purity of the product, or to determine the range of output and product purity over which the plant can be operated most economically. One of the contractor's executives would in general be present, at least during the early stages, to advise the manufacturer how he can best achieve his requirements, for example, by various changes in operating techniques. It is further possible that the manufacturer may consider, as a result of his testing, that the contractor has not met his guarantee. A further test, namely a guarantee test, would then have to be carried out, probably dislocating production and duplicating a test run. This is another reason for testing while one of the contractor's executives is present, since he can assist in locating any difficulty.

As regards testing, the contractor provides a service to the manufacturer and he therefore has to be paid for this work.

A guarantee test is carried out by the manufacturer to prove to the contractor, who is represented, that he has

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† 60 Drayton Gardens, Winchmore Hill, London, N.21.

fallen down on his guarantee. The manufacturer again arranges and pays for all necessary materials and services to be provided, this time at the specified and agreed conditions, and operates the plant. The contractor's representative assists in locating the cause of the discrepancy, perhaps caused by circumstances beyond the contractor's control such as lack of maintenance or faulty operation of the plant by the manufacturer's labour. The proving run is carried out over an agreed period of time. In the event of performance being limited by the manufacturer's inability to supply materials and services at the specified conditions, then performance cannot be questioned and the manufacturer has failed to prove his point. The contractor's representative, however, may conclude that, even for this case, sufficient evidence has been presented to show that the contractor has a problem to solve.

Because it is the manufacturer who has to prove that a guarantee has not been maintained, the contractor has to be paid for work he does in proving; that is, for guarantee testing. A possible exception may be when it is proved that the guarantee has not been maintained, the work entailed in the proving run then assisting him in locating and eliminating the difficulty.

The contractor determines the extent of commissioning required and also the extent to which he has to satisfy himself that the guaranteed performance has been achieved. In general, the work he will do in this respect is stated in his quotation. Any assistance required by the manufacturer in connection with training of operators, testing and proving, when these are not specifically defined and stated in the quotation, is an additional expense which the manufacturer has to meet.

When a contract contains penalty clauses related to guarantees of performance and delivery, it is again the manufacturer who has to prove default. The delivery period may be taken to commence on the date the order is acknowledged unless the contractor's quotation clearly states that it commences from receipt of full and final instructions. These permit the contractor to proceed without further alteration of requirements on the part of the manufacturer. When penalty clauses are accepted by the contractor, they should be balanced by bonus clauses, the contractor earning a premium when performance and delivery are better than guaranteed. As the manufacturer is responsible for producing, the contractor does not indemnify the manufacturer against loss resulting from inadequate performance or from late delivery.

The points made here as applying between manufacturer and contractor appear to apply equally well between contractor and sub-contractor.

Manufacturer's Contracting Activity

The manufacturer's engineering organisation provides a specialist service to his producing organisation. The engineering department serves the production department and the associated engineering company serves the parent producing company. The manufacturer's engineering organisation, rather than independent contractors, provides plants so as to prevent know-how from leaving the organisation. The function of the manufacturer's engineering organisation is the provision of plants and it is, therefore, a contractor.

The manufacturer's engineering organisation need not make a profit, its success being more often judged by output and quality of product from the plants it provides. There is thus a tendency to overdesign, a contributory factor being that no competing bids are received by the producing organisation. Without competition there is no criterion by which the effectiveness of the engineering organisation's work can be judged. Success of product produced is not a criterion, as it might have been greater had the work been done more effectively. The engineering organisation has a considerable measure of security, since it is assured of both orders and financial backing from the associated producing organisation.

The contractor has to make a profit while competing with other contractors. He has every incentive to reduce costs, to improve his designs, methods and the processes he offers. While in his case the incentive to improve stems from the need to survive competition, in the case of the manufacturer's engineering organisation some drive to improve would come from the associated producing organisation, who may feel that their engineering organisation is not doing its work as well as it might. However, this may result not in the engineering organisation becoming more effective, but in some of their work being duplicated by the producing organisation, who consider that they can do it better. When this happens the producing organisation has lost sight of the main function of the associated engineering organisation, which is not that of successfully providing plants but that of retaining process information within the parent organisation.

The contractor's competitive position is shown by his annual profit and turnover compared with that of his competitors. There is generally no similar criterion of survival or effectiveness applied to the manufacturer's engineering organisation.

Sometimes it is apparent that the manufacturer keeps his know-how to his own organisation at some considerable cost to himself, and, as a result, plants are not likely to be provided effectively. This undoubtedly affects his position

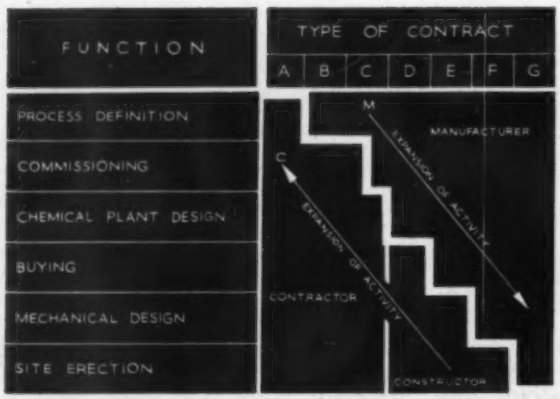

Fig. 10. *Chart showing field of activity (dynamic).*

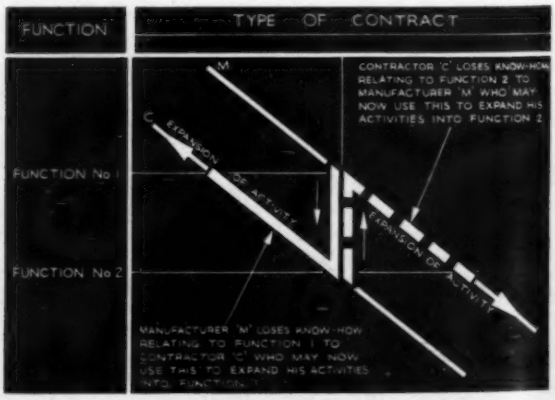
FUNCTION
TYPE OF CONTRACT
M
CONTRACTOR 'C' LOSES KNOW-HOW RELATING TO FUNCTION 2 TO MANUFACTURER 'M' WHO MAY NOW USE THIS TO EXPAND HIS ACTIVITIES INTO FUNCTION 2
C
EXPANSION OF ACTIVITY
FUNCTION No 1
EXPANSION OF ACTIVITY
FUNCTION No 2
MANUFACTURER 'M' LOSES KNOW-HOW RELATING TO FUNCTION 1 TO CONTRACTOR 'C' WHO MAY NOW USE THIS TO EXPAND HIS ACTIVITIES INTO FUNCTION 1

Fig. 11. *Disclosure of "know-how" (conflicting interests).*

compared with that of his competitors unless, of course, their plants are also being provided by an associated engineering organisation.

When the manufacturer enters the field of contracting, there then exists the possibility that the manufacturer's engineering organisation may use know-how relating to plants built by independent contractors, in order to design and construct similar plants. A parallel situation exists between contractors and sub-contractors.

As regards the provision of plants, the conflicting interests of contractor and manufacturer are illustrated by Fig. 10. It is seen from the way in which the diagonal line, which indicates the division of work, divides the field that the manufacturer's contracting work is an extension of his work on processes, and that the contractor's process work is an extension of his contracting activity. The constructor, as he grows, expands into contracting, and thence through activities concerned with processes to the providing of specific complete process plants. The manufacturer expands his activities through chemical engineering design, whilst using constructors, until in the end he provides the specific complete process plant himself.

The opposing interests of manufacturer and contractor are further illustrated by Fig. 11, the field of activity being that of Fig. 10. The diagonal lines represent manufacturers and contractors respectively. As vectors on a field of activity, the diagonal lines also state the direction of expansion along both axes. The division of work for the particular contract illustrated occurs between functions 1 and 2, this defining the type of contract on the field. The illustration shows how know-how obtained in the course of a contract by a manufacturer from a contractor may be used by the manufacturer to extend his activity to embrace that of the contractor. The manufacturer then takes over some of the contractor's work, thus becoming a competitor. This process continues until, in the end, the manufacturer even erects his own plants. Similarly, the constructor, who was initially concerned with field erection only, finally extends his activities so that they include the search for new processes.

However, the sequence is not yet ended. The manufacturer's engineering organisation in the first place supplies plants only to his own producing organisation. Eventually, it supplies unit plants and plants to other manufacturers as well, in open competition with contractors. While doing so it may still not have to show a profit, because of the strong backing it receives from the parent organisation, by direct or indirect subsidy.

As against this the author knows of no case where the contractor has developed a process, built the plant, and then proceeded to operate it at his own risk so as to sell the products for profit.

Both contractors and manufacturers must prevent their respective know-how from becoming known to their competitors by either party to a contract. The manufacturer may not appreciate the value of the contractor's know-how to the contractor, or indeed may not appreciate just what constitutes this know-how. In addition, the manufacturer may consider that the contractor's know-how becomes his when he buys a single plant. As a result, the manufacturer cannot be relied upon to protect the contractor's interests. As a consequence, the contractor has entered the manufacturer's field of processing, but only in so far as he obtains licences for processes, develops processes and offers plants in which a specific process is carried out. Such process plants are obtainable only from a restricted number of contractors until the time arrives when the process and the corresponding process know-how have become available to other contractors. On the other side the manufacturer, to protect his own know-how, sets up engineering organisations which, in so far as they are contractors, compete with independent contractors by taking work away from them. In the end the manufacturer's engineering organisation enters into open competition with the contractor.

Whilst the contractor does not compete with the manufacturer in producing, the manufacturer competes with the contractor in the provision of plants. Hence it appears that the manufacturer's preoccupation with competition amongst manufacturers has created a situation in which, almost whenever an order for a unit plant or plant is placed, the contractor's know-how is disclosed to his customer who is at the same time a potential competitor; at the same time it is more than likely that it will be disclosed to existing competitors.

Since the relationship between contractor and manufacturer is a functional one, the two ought to work together as a team. On the contrary, both fear, and occasionally suffer from, disclosure of know-how to competitors. When this happens the contractor has taken no effective steps to prevent such disclosure, relying as he does on the manufacturer to provide his livelihood. Manufacturers for their part have formed associated engineering organisations to protect themselves, which results in conflicting interests instead of team-work.

Processes and Plants

Here we are considering a hypothetical example which is, however, typical. A manufacturer improves a process and, should he wish to apply for a patent, he would have to give the process improvement and to describe how it can be effected. Let us assume that the process improvement consists of adding a comparatively small quantity of a chemical to one of the process streams and that this results in an increased rate of mass transfer in an adsorber and in a reduced temperature of reactivation elsewhere. The higher mass-transfer rate means a better product or increased recovery and, alternatively, a smaller and therefore cheaper adsorber. In addition, the reduced reactivation temperature implies that reactivation costs can be reduced in a number of different ways, using different materials of construction, various sources of low-grade or low-cost heat and various arrangements of exchangers. The manufacturer might well consider that the main advantage would be the economies resulting from the lower reactivation temperature, and may consequently file a patent application for the process as a whole whenever low-grade, low-cost heat is used in various exchanger combinations. He would then have covered both the process and the plant in which it takes place.

All advantages stem from the addition of a relatively small quantity of a chemical to one of the process streams and this is a process improvement, unrelated to the already known plant in which it takes place. The improvement consists of adding a certain chemical in defined proportions or quantities to one of the process streams, the means consist of a way of introducing the chemical in the required amounts into the process stream, and the advantage lies in the consequent economies, that is, in a cheaper product. Hence it would appear that a process is a matter entirely distinct from the plant in which it takes place.

The actual arrangement of exchangers and the source and cost of low-grade heat that would be used would depend, in each particular application, both on the customer's requirements and on the experience and ingenuity of the designer. In so far as they depend on a manufacturer's requirements, they would be determined by process considerations, that is, by considerations peculiar to the manufacturer. To the extent to which they depend on the contractor's choice they would be a matter of design, that is, they would concern the plant. Hence the manufacturer's requirements define the process and the contractor's freedom of choice concerns the plant.

We can consider in more detail the distinction between

process and plant with the help of a further example; namely, some of those processes which are concerned mainly with the unit operation of adsorption, more particularly with adsorption from gases.

The manufacturer names the process in accordance with his requirements. It is a "recovery" process when a valuable constituent is being recovered, "purification" when an undesirable constituent is being removed, and "filtration" and "drying" when it is oil vapour and moisture, respectively, which are being removed. The name he gives to the process thus gives some idea of his requirements. In addition, the manufacturer determines whether operation should be continuous, intermittent, manual, semi-automatic or automatic, the permissible overall pressure drop and the cycle time, the required inlet and outlet concentrations, operating conditions such as temperature and pressure, as well as the rate of flow of the process gas. He further determines the extent to which process gas has to be used for reactivation, considering the value and the required purity of the process gas. To the extent that the reactivation circuit depends on the manufacturer's requirements, it is a process consideration, as is the type of heating medium used for reactivation, and the maximum available quantity, and the quality, of the process stream which is available for any necessary cooling. These, then, are the process considerations for this case, and assistance is rendered to the manufacturer, in the form of quotations, to enable him to choose, for example, the most economic process conditions. In this connection it has to be remembered that the manufacturer has in addition to decide whether "adsorption" or some other unit operation best meets his requirements.

The contractor designs the adsorber, determines the number of adsorbers to be used and the type of adsorbent, the way the gas flows through the adsorbers, individually and collectively, during the various stages of the cycle, decides requirements of, or designs, the auxiliary equipment such as fans, heaters, coolers and separators, sizes pipelines and valves, designs the indicating and control instrumentation; he lays out the plant and does the necessary drawing, fabricating, procuring, carries out erection and delivers the plant. He guarantees that the performance of the plant meets the process requirements stated to him; in other words, he guarantees that the work he has undertaken will be done satisfactorily, stating the performance of the plant and the services required, all this being conditional upon the manufacturer having correctly and completely defined his requirements to the contractor in so far as process, process requirements and process conditions are concerned.

A clear line of demarcation can be drawn, for each case, between the matters which are decided by the manufacturer, and those which are decided by the contractor. Or put otherwise, a clear distinction can be drawn, in each case, between the process and the plant in which it takes place.

The following points arise:

(1) In each case it is possible to differentiate clearly between a process and the plant in which it takes place.

(2) Processes are the concern of manufacturers, and of manufacturers only, and process data should not be disclosed by a contractor to any other party without the agreement of the manufacturer from whom it was obtained in the first place, irrespective of whether or not an order is placed.

(3) Plants are the concern of contractors, and of contractors only. Manufacturers should not disclose design or plant data without the agreement of the contractor who supplied the data or the plant in the first place. It is implied that the contractor should not be asked unnecessarily to disclose data which he considers confidential. These points apply whether an order is placed or not.

(4) It seems necessary to oppose patent applications which confuse processes and plants, or processes and plant items. A patent application should cover either a process or a plant, but not both.

(5) It would appear that any process improvement which arises during the course of a contract should belong to the manufacturer. Similarly, any design or plant improvement should belong to the contractor. The improvement could not have been made had the relevant basic data not been disclosed. For example, useful test results on the plant should in any case be reported back to the contractor who supplied the plant in the first place. A specified time interval could be agreed between manufacturer and contractor, after which know-how may be disclosed.

(6) These various points applying to manufacturer and contractor apply with equal force to contractor and sub-contractor. For example, with the larger projects such as nuclear power station projects, the manufacturer states his process requirements to the contractor whose freedom of choice then covers a number of alternatives of plants, plant units and arrangements of them.

Processes and Treatments, Plants and Operations

The manufacturer processes raw materials to obtain saleable products. These products may be the raw materials which, in turn, may be converted to yet other products. It is the overall change, and the treatments applied to produce this change, which constitute the process.

One manufacturer may convert raw material A to product B which is transferred elsewhere to be converted to product E. Writing, for example, AB when we mean "conversion of raw material A to product B", we can relate the individual processes with the overall process:

$$AB + BE = AE \quad \ldots . (1)$$

Another manufacturer may consider that, in his case, it is more economic to convert A to another product, C, which, in turn, is converted to E. His processes can then be represented by AC and CE, and the overall process is:

$$AC + CE = AE \quad \ldots . (2)$$

Yet another manufacturer may convert A to E by three consecutive processes, extending his production facilities in stages, installing one plant at a time:

$$AC + CD + DE = AE \quad \ldots . (3)$$

Equations (1), (2) and (3) and the processes they contain represent groups of processes in so far as only the treatment is specified. Raw materials may differ in form and analysis and different manufacturers may require the products to be in various forms and of different purities. Denoting such differences by suffixes, we can write down just a few of the possible processes which take place when A is converted to E, for the groups of processes represented by Equations (1) and (2), thus:

$$A_1B + BE_1 = A_1E_1 \quad \ldots . (1a)$$
$$A_2B + BE_1 = A_2E_1 \quad \ldots . (1b)$$
$$A_1B + BE_2 = A_1E_2 \quad \ldots . (1c)$$
$$A_2B + BE_2 = A_2E_2 \quad \ldots . (1d)$$
$$A_1C + CE_1 = A_1E_1 \quad \ldots . (2a)$$
$$A_2C + CE_1 = A_2E_1 \quad \ldots . (2b)$$
$$A_1C + CE_2 = A_1E_2 \quad \ldots . (2c)$$
$$A_2C + CE_2 = A_2E_2 \quad \ldots . (2d)$$

The number of alternatives shown are a very small sample. For example, the intermediate products B and C are assumed to have constant form and purity. Their form and purity are important factors when considering the profitability of further conversion, and each manufacturer is likely to have his own specific requirements. Thus there exist a very great number of different processes.

The manufacturer divides his process into what one might call "unit processes", but which are more clearly defined as "treatments". Examples are purification, recovery, filtration, drying, hydrogenation, conversion, and so on. This terminology enables the manufacturer to describe his particular requirements, that is his process. For example, a raw material may have to be purified and then filtered, the filter cake having to be dried and a constituent being recovered from the filtrate. No particular significance can be attached to the subdivision of processes into treatments. The same treatment may be "purification" to one manufacturer and "recovery" to another.

It is seen that treatments and processes may vary from manufacturer to manufacturer, and that they are no more than descriptions of how a particular manufacturer converts, or intends to convert, a raw material into a product. Bearing in mind that processes consist of at least one treatment, and that it is in the terminal conditions that plant and process meet, the contractor may then expect to get inquiries for plants for a large number of processes, examples being A_1E_1, A_2E_2, A_1B, BE_2 and C_1D_1. If one process differs from another only in the purity of raw material and product, he provides plants which may be similar. But as a plant is provided so that a particular process can take place in it, a plant is designed to meet the requirements of the particular customer. Because of the large number of processes, and so that plants can be provided effectively, the contractor divides the plant functionally into a number of unit plants. Each unit plant carries out a unit operation, and only in so far as these are independent of processes can plants be assembled from unit plants.

A gas drying treatment is carried out not in a unit plant but in a plant which is made up of a number of unit plants, examples being the adsorber and the heat exchanger. The unit operation of adsorption is carried out in a unit plant called the adsorber and heat exchange is carried out in a heat exchanger. A drying installation is thus a plant, differing from other plants in the number, type and arrangement of unit plants. This illustrates that there is in general no correspondence between the manufacturer's "treatment" and the contractor's "unit operation". As process and plant are separate and distinct matters, one should not expect such correspondence. Further, a number of different types or arrangements of unit operations may be available for carrying out the one treatment.

It has been said that a process is made up of unit operations in their proper sequence. Manufacturers, however, do not describe processes in terms of unit operations, as this would be far too cumbersome. Plants are assembled from unit plants in which unit operations are carried out and from the point of view of the chemical engineer and contractor the essential characteristic of a unit operation is that it is independent of the processes for which it is used.

This being so, one may classify unit operations accordingly. In addition, when it is seen that a plant is distinct and separate from the process which takes place in it, then it can be appreciated that the training of the chemical engineer should emphasise the engineering aspects rather than the chemical aspects.

(To be continued)

Oil Blending Units for New Ocean Terminal

THE Fisher Governor Co. Ltd., a member of the Elliott-Automation Group, has just completed the commissioning of four large "In-line fuel oil blending units" for the Mobiloil Co. at their new Ocean Terminal at Ellesmere Port in Cheshire. The installation enables varying grades of fuel oil to be supplied to loading arms for road and rail tankers and maintains the specification of the oil to within $\pm 1\%$ of the desired viscosity, an accuracy not previously achieved by commercial distributing installations in this country.

The design of the blending units uses the principle of parallel metering of two fluid components and the establishment of equal pressures at the point of metering, a method which achieves a high accuracy of blend without the need of an external source of operating power.

In this particular installation Mobiloil wanted to achieve an exceptional degree of accuracy in the blend at an unusually high rate of flow. To meet the increased maximum flow requirement, Fisher developed a modified design of its standard blending unit with 10-in. and 6-in. heavy and light oil component arms respectively, with a 12-in.-diameter outlet. To ensure homogeneity of blend at the outlet of the unit and before the measuring point of the controller, a mechanical mixer was installed.

To achieve the additional accuracy of blend required it was decided to fit to each of the Fisher blending units a Smiths viscosity control unit especially developed for this particular installation, thus making the installation self-compensating for changes in the viscosity of the component fuels. Each unit of the Ellesmere Port installation is now capable of blending oils to produce viscosities of 200 to 1500 seconds Redwood No. 1 in proportions of 97:3 to 60:40 and at flow rates ranging from 0 to 1400 gpm to within the overall accuracy called for of $\pm 1\%$ of the desired viscosity value.

One of the main advantages of Fisher blending units is their simplicity of design. By their use the oil companies are able to give their customers a wide selection of fuel oils without the necessity of storing the many different grades of oil required today.

The design of the blending units is such that they may be used in any industry where two liquid products require to be mixed in certain volumetric proportions.

Two arms of one of the four Fisher blending units recently installed at Mobiloil's new Ocean Terminal at Ellesmere Port in Cheshire, showing the electrically-operated metering valve in the light component line.

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ASPECTS OF THE DEVELOPMENT OF THE FRODINGHAM GAS DESULPHURISING PROCESS

Fluidisation technique has been applied to sulphur removal from gases by iron ore and subsequent regeneration of the ore

by S. A. GREGORY, B.Sc., M.I.Chem.E.*

THE Frodingham gas desulphurising process uses a reactor containing hot iron ore fluidised by the stream of gas from which the sulphur is being removed; the ore is regenerated by continuous circulation to and from another reactor where the sulphur is burned off the iron ore by a stream of fluidising air. The process has been described in considerable detail by Reeve.[1] The purpose of the present paper is to discuss some aspects of the development of the process and plant having particular interest to chemical engineers.

Derivation of the Process

The ability of hot iron oxide to absorb hydrogen sulphide readily was emphasised following an investigation of the sulphur balance of an open-hearth furnace. This investigation showed that sulphur originally contained in crude debenzolised coke-oven gas as hydrogen sulphide was reduced in quantity by passing through the checkers of an open-hearth furnace fired with a mixture of blast-furnace gas and coke-oven gas. The sulphur was absorbed from the mixed gas upon iron oxide held in the checkers. As a result of this, less sulphur entered the combustion zone. On reversing the flow through the checkers, as in normal furnace operation, the sulphur on the checkers was burned off by residual oxygen in the outgoing flue gas from the furnace.

Following the demonstration of this "natural" process, there were suggestions for carrying out the process of desulphurisation more directly. An early suggestion was that the process should be accomplished by passing the gas through hot checkers made of iron oxide. This was abandoned because of the difficulty of obtaining suitable checker bricks. Another method suggested the use of oxide boxes, similar to the boxes at low temperature in the town gasworks, but run hot.

These two methods had the possible advantages of being simple and exerting low pressure drop on the gas being processed. Disadvantages were large heat losses, the need for switch-over equipment, the need for purging between absorption and regeneration, possibly a large charge of iron oxide.

Any application of the basic process required a method of bringing about contact between a gas and a solid. Other possibilities available included fluidisation and moving burden techniques. Since moving burden implied the use of oxide briquettes or pellets it did not recommend itself. There is at present a satisfactory moving burden, desulphurisation process—the Gastechnik process—but it operates cold, and solvent leaching is used to remove the accumulated sulphur. The Gastechnik process suffers from the breakdown of pellets. In 1950 laboratory tests showed that absorption of sulphur took place readily in hot fluidised iron oxide.

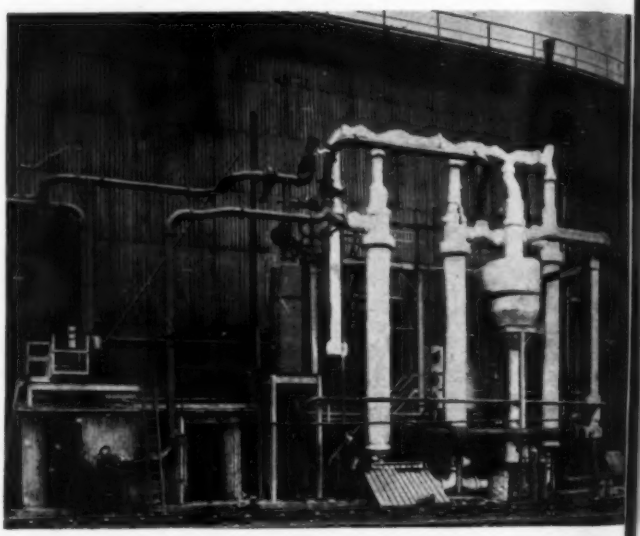


Fig. 1. General view of pilot plant for desulphurising coke oven gas.

Evolution of the Fluidised Process

Although a fluidised sulphur absorption process had been claimed in 1950, the economic evaluation had not been pursued in any detail. However, later the steelworks required a large pilot sulphur removal plant in order to test the value of low sulphur in the fuel for steel making, and it appeared that a fluidised plant might be built more cheaply than any conventional plant. A large part of the bias towards the use of fluidisation came from the substantial experience of fluidisation technique and the building of fluidised reactors which existed in Frodingham Research Department.

* Mr. Gregory is with A.E.I. Birlec Ltd., Birmingham, 24.

Characteristic of a fluidised process is the fairly large pressure drop of the gas in passing through the absorption reactor; also there is the problem of dealing with dust from the fluidised bed. It was possible to justify the use of the fluidised process in the steelworks experiment because of low capital cost. For industrial operation an immediate drawback to the process would be the cost of power for blowing gas through the plant.

Since there appeared to be little chance of a large-scale plant obtaining a credit from the steelworks for the removal of sulphur, the recovery of some valuable material from the process was necessary in order to offset the cost of operation. The obvious valuable product was sulphuric acid, which was already being produced in such desulphurising processes as that of Collin installed at Corby.[2]

Since sulphuric acid was to be made it meant that the regeneration part of the Frodingham process had to be designed to produce sulphur dioxide of suitable strength. This fitted in readily with the existing proposals for working the process.

In all processes likely to be of value the iron oxide is alternately subjected to absorption and to regeneration. This means that at one stage the oxide is in contact with combustible gas and later with air or oxygen-rich flue gas. For safety it is essential to have some purge system between the gas circuit and the air circuit. For the fluidised process the simplest method was to interpose a small-diameter fluidised vessel through which the regenerated oxide had to flow before returning to the absorption vessel. This intermediate vessel discharged its purge gas to atmosphere. Another similar vessel was placed between the adsorber and the regenerator.

All the coke-oven gas passing through the process required to be heated to reaction temperature. This was partly done by the transfer of sensible heat from the regenerated ore, partly by the combustion of coke-oven gas in the absorber with traces of oxygen. To make the process self-supporting, any difference had to be made up by using the sensible heat of the purified coke-oven gas to heat up the incoming gas. It is interesting to note the resemblance between the operational heating required for this process and that required for the North Thames Gas Board process for removal of organic sulphur. Similar temperature requirements exist for the German "Luxmasse" system.

Principles of Pilot-plant Design

The problems to be overcome in the design of a suitable pilot plant sprang from a number of different demands.

(1) In the first place the pilot plant was intended to be a cheap means of removing sulphur in order to carry out steel-making experiments.

(2) If the steel-making experiments were successful, or if the gas desulphurisation tests were successful, then there would be a need to go ahead with a larger plant. Hence the pilot plant must supply essential process data and, if possible, test out the design features of a future large-scale plant.

To obtain cheapness in construction, five lines of approach were used. The first of these involved building the plant with a minimum of expensive protective material, and making the mild-steel construction itself as light as possible. The second was based on the use of relatively high velocities in all pipework, so that pipe and valve diameters could be kept to a minimum. The consequence of this was a relatively large pressure loss in the pipe systems compared with normal practice. Then by-passes and alternative routes were kept few. The most important of the by-passes were around the heat exchangers and the scrubber. The plant units were kept as simple as possible, and complex instrumentation was not encouraged. The maximum of plant was to be designed and constructed by internal resources.

Since the fluidised process had only been worked in laboratory-size batch beds there was little information about the chemical changes taking place during the continuous process as it was likely to occur in the full-scale plant. Nevertheless, upon this minimum of chemistry, flow-sheets had to be prepared. Guesses had to be made about the state of reduction prevailing in the absorber bed, the type of iron sulphide made and the quantity of gas used in reduction or by oxidation. Upon this hypothetical chemistry the heat balance of the plant had to be forecast.

Assuming that the pilot plant would be successfully operated the ground had to be prepared for the design of a larger plant. In order to set up the pilot plant correctly, therefore, it was necessary to outline the probable design of the large-scale plant so that, in the light of this forecast, the pilot plant should incorporate units suitable for ready magnification to the larger plant.

Interwoven with all these considerations was the fact that the pilot plant was to be an experimental demonstration of the desulphurisation process and, therefore, had to be equipped with enough suitable sampling points and measuring devices. Moreover, there must be sufficient flexibility for variation of process conditions built into it to determine the best basis for operation.

Design of Pilot-plant Fluidised Reactors

Essentially, the plant required two main fluidised reactors: the absorber and the regenerator. The absorber was to treat at least 120,000 cfh gas. The approach to the design of such reactors has been considered by the author.[3]

Absorber

Functional Element	*Design Basis*
1. Gas inlet.	Reasonable pressure drop.
2. Gas distribution.	Sparge pipe with small pressure drop. Distribution plate derived from prior work.
3. Solids inlet.	Direct from purge bed, size of pipe by test.
4. Solids distribution.	Occurs by fluidisation.
5. Gas/solids separation.	First stage by gravity; height by prior test. Second stage by external cyclone to prevent accumulation of fine material in the reactor.
6. Gas collection.	Direct flow to outlet.
7. Gas outlet.	Reasonable pressure drop—flow is to cyclone.
8. Solids collection.	Direct flow to outlet.
9. Solids outlet.	Pipe to purge bed, size by prior test.
10. Gas/solids contacting.	To be determined.

A similar approach was used for the design of the regenerator. The background of experience was such that there was little doubt about the good process performance of all the functional elements with the exception of the fluidised bed itself. The bed could be designed so that it would fluidise satisfactorily, but the depth required for adequate desulphurising would have to be guessed.

The original laboratory work on fluidised sulphur removal used a 5 cm diam. vertical tube containing a batch bed. The proposed pilot, using a similar fluidising velocity to that employed in the laboratory work, would involve a magnification factor of about 1500. This seemed unduly large to make any reasoned forecast of bed depth.

The time available for experiment was short and it was not feasible to set up any small continuously-circulating system operating the process. Batch tests were made with a 6-in.-diam. absorber. This gave sulphur removal comparable with the 5-cm tube, using similar depths of bed. The magnification factor from this reactor to the pilot plant was about 170. It was therefore resolved to design the pilot absorber to accommodate a bed depth at least twice that of the first experiments.

A further requirement of the design was to circulate the iron ore from the absorber to the regenerator and back again. The method chosen was to convey the ore pneumatically by air from the overflow of the purge reactor after the absorber up into the regenerator, allowing gravity flow back from the regenerator to the absorber. From process considerations it might be better to convey the ore from the regenerator overflow by a stream of gas. But such a circuit would require the absorber vessel to be at a higher level

than the regenerator. In the pilot plant it was cheaper to place the regenerator at the higher level. To demonstrate the feasibility of the flow system a rig was set up containing fluidised vessels with transparent walls.

Apart from the items which were necessary for running the pilot plant, equipment had to be designed to assist the starting of the plant. The principal requirements were a boost heater for the gas entering the absorber, draught for it being producted by a steam ejector, and gas burners for heating the fluidised contents of the generator. Supplies of suitable iron ore could be made in plant already existing in Frodingham Research Department.

Materials and Construction

The principal parts of the plant expected to cause difficulty were those subjected either to erosion or to corrosion at temperature. Erosion was to be avoided as far as possible by confining regions of high-velocity flow of solid to straight lengths of pipe. In practice, this had most significance for the pneumatic conveyor. The most likely cause of corrosion in the absorber circuit was expected to be due to hydrogen sulphide where the temperature exceeded 350°C. This was supported by evidence from the petroleum industry.[4] In the regenerator circuit protection against high temperature was to be obtained from the use of good-grade refractory brick.

In all cases it was thought reasonable to use a minimum of protective material and to employ as much mild-steel construction as possible, since the plant was not intended to last much more than a year. Tests for thinning over the working life would indicate the sites of worst corrosion or erosion and enable suitable precautions to be taken on a full-scale plant. A small amount of stainless steel was proposed for hot spots where the use of refractory would be inconvenient.

Distribution Plate Design

In laboratory work the beds of iron ore were supported upon plates of suitable material, such as insulating refractory brick drilled with holes approximately $\frac{1}{8}$ in. diam. These holes were small enough to prevent the downflow of ore particles, because bridging readily occurred in holes of this size. For small-scale pilot-plant operation a similar type of plate is practicable. In this case the plate is more conveniently made of metal and held on flanges. Distribution plates of 4 in. or 6 in. diam. are not difficult to make.

For larger plants some attention had to be given to the construction of the distribution plates in order to obtain a relatively cheap method of manufacture. The general method adopted in the present case was to take advantage of the bridging principle but to obtain it in horizontally disposed slots instead of in vertical cylindrical holes.[5] By using the horizontal slot principle, it is possible to construct distribution plates from a number of strips of suitable metal, each strip having its edges under or over those of its neighbours, thereby forming the slots.

The dimensions of the slots were determined in the following way. First, the total slot area through which the fluidising gas passes horizontally before emerging into the mass of particulate solid is based upon the choice of a horizontal gas velocity which is adequate to convey any particles away from the neighbourhood of the slot. For example, the slot velocity may be chosen to be 30 ft per sec. That this is a satisfactory velocity may be checked by setting up such a plate and spreading a thin layer of the particulate solid upon it. On blowing air or gas through the plate at the designed velocity the solid should be blown away from the neighbourhood of the slots. Tests of the design which was employed showed that it was possible to maintain the ore in motion very well across the whole of the plate.

The ratio between the chosen overall fluidising velocity and the slot velocity gives the relationship between the slot area and the cross-section of the bed. Thus, with a fluidising velocity of 1 ft per sec. and a slot velocity of 30 ft per sec., the slot area is 3.3% of the bed cross-section. The permissible slot width for a given mixture requires to be checked by experiment. The width is only important if it is necessary to prevent substantial flow-back of solid.

Construction of the Plant

Sanction was obtained to go ahead with the plant. The plant had been designed for simplicity of construction and it was decided to build as much as possible with internal resources. Large vessels were to be made by United Steel Structural Co. Ltd. and smaller items and assemblies were to be made in the workshop of Frodingham Research Department. The principal items to be purchased outside were the main gas blower and a proprietary gas scrubber for the removal of fine dust.

Since the plant was to produce treated coke-oven gas for use in open-hearth furnace trials, it had to be located in the vicinity of the Appleby Melting Shop. A spare site of limited dimensions was found at the north corner of the shop. This site was at the side of a railway track so that it lent itself to service by steam crane. Because the site was restricted, it meant that some care had to be taken in fitting in the plant items. It was considered that the items most likely to need attention would be the heat exchangers, since they had been designed with 18-gauge mild-steel tubes. To save space they were arranged to be mounted vertically on the side of the plant near the railway track so that, if necessary, they might be lifted out by crane.

The main blower was arranged to be near the corner of the shop to connect with the new gas supply main which would be required to connect the Melting Shop gas system to the pilot plant. The blower was to be driven by a 100-h.p. electric motor, the motor being installed on the other side of a wall. The control room was set out between the blower shed and the plant proper. Apart from the gas blower motor, this room contained the two air blowers used for the regenerator.

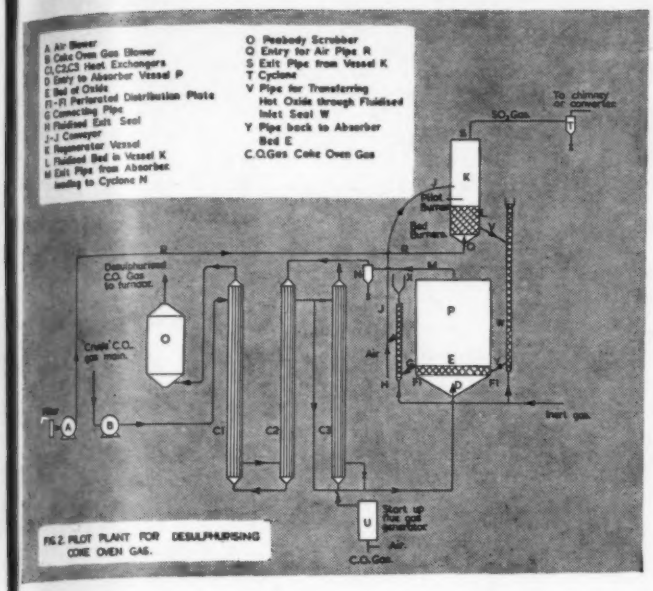
The instrument panel was arranged to be in a section of the control room separated from the air blowers. Instruments were chosen to be as simple as possible. Most of the instrumentation, in accordance with the requirements of a fluidised process, consisted of flowmeters or pressure gauges. The instrument panel was, therefore, largely an array of manometers. No automatic controls were used, although some alarms and trips were installed.

The absorber was located on the other side of the instrument panel. Beyond the absorber was the regenerator. In order to dispose of flue gas from the regenerator, which would be rich in sulphur dioxide, a vent pipe was run from the regenerator cover to the cyclone and from thence to the stack of one of the furnaces.

Plant Commisioning

Construction began on the plant site in September, 1955. The plant was ready for commissioning by March, 1956, although some trials were started in January, 1956. Because of the relatively large size of the plant, particularly the absorber, it was decided to test with air fluidisation extensively. So that tests might be satisfactorily carried out with air a positive blower had been chosen for the main gas circuit. A centrifugal blower suitable for coke-oven gas would not have been satisfactory for air testing.

The item of greatest interest was the fluidisation of the absorber. A manway had been fitted with a glass window at a level just above the distribution plate so that the appearance of the fluidised bed could be seen from the side. After the absorber had been charged with suitable ore the


A Air Blower
B Coke Oven Gas Blower
C1,C2,C3 Heat Exchangers
D Entry to Absorber Vessel P
E Bed of Oxide
F1-F1 Perforated Distribution Plate
G Connecting Pipe
H Fluidised Exit Seal
J-J Conveyor
K Regenerator Vessel
L Fluidised Bed in Vessel K
M Exit Pipe from Absorber leading to Cyclone N
O Peabody Scrubber
Q Entry for Air Pipe R
S Exit Pipe from Vessel K
T Cyclone
V Pipe for Transferring Hot Oxide through Fluidised Inlet Seal W
Y Pipe back to Absorber Bed E
C.O.Gas Coke Oven Gas
To chimney or converter
SO2 Gas
Pilot Burner
Bed Burners
Desulphurised C.O. Gas to furnace
Crude C.O. gas main
Air
Inert gas
Start up flue gas generator
Air
C.O.Gas
FIG 2. PILOT PLANT FOR DESULPHURISING COKE OVEN GAS.

blower was put on. As the blowing rate was increased it was found that a shallow bed of ore appeared to behave well when viewed through the window. Since the behaviour near the window might have been exceptional, the appearance of the whole bed was inspected visually through a manway on the top cover of the vessel. The surface showed large bubbles breaking at random every now and then. This behaviour resembled that noted in earlier observations in an experimental rig, and was in accordance with expectations.

To make certain that the bed was satisfactorily fluidised and free-flowing, a pole was lowered into the bed and moved about in an effort to find dead spots. It was particularly important to check the neighbourhood of the inlet and outlet ports to make certain that free flow would be obtained when circulation was attempted. The fluidisation of the regenerator was assumed to be satisfactory because its conditions and dimensions were similar to many which had already been operated in the department. To obtain satisfactory fluidisation cold, it was, of course, necessary to blow more air than would be needed when the reactor operated at correct process temperature.

After fluidisation of the two main vessels had been checked it was necessary to obtain circulation of ore around the plant. The flow-rate of ore was to be indicated by pressure difference across two tappings on the pneumatic conveyor. This system required calibration. The successful attainment of circulation, with air blowing under hot conditions was reached in March, 1956.

Why Did the Plant Work?

The plant operated satisfactorily and details of its performance have been given. With a single bed in the absorber it was possible to obtain up to 90% removal of sulphur from debenzolised coke-oven gas. Sustained operation over a number of campaigns provided the opportunity to judge the utility of desulphurisation of the fuel in the open-hearth furnace. Following these successful demonstrations, a large-scale plant has been ordered sufficient to treat the total make of gas at the Appleby-Frodingham coke ovens. This plant is being commissioned. Its design stems from the studies which were made in conjunction with the design and operation of the pilot plant.

Reasons which may be suggested for the success of the plant are:

(1) the process was simple, consisting of two stages;
(2) there were normally no sticky products of intermediates;
(3) there was little corrosion;
(4) the process operated at near-atmospheric pressure; and
(5) the considerable background of experience in Frodingham Research Department in the design and operation of fluidised reactors.

Two unknowns might have been held to jeopardise the magnification of the process. The first of these was the behaviour of shallow fluidised beds of large diameter. The first doubt was not considered to be important. Already tests had been made in a rig with a bed 8 ft long and 1 ft 3 in. wide. This had shown the possibility of obtaining fluidisation with random bubbling using a distribution plate design of the type ultimately used. Satisfactory performance was obtained in this rig with beds as shallow as 3 in.

The second doubt was considered to be important. This concerned the reported inefficiency of large-diameter beds due to "back-mixing" of the gas. Even here the evidence was unsatisfactory or conflicting, but the indication of the most recent large-scale experiment on the subject had been against substantial back-mixing.[6] Even if it became possible to rule out the influence of back-mixing, there remained the undoubted fact that other people had found difficulty in obtaining satisfactory performance with magnification.

The behaviour of the present plant suggests that the important factor which affects performance on the magnification of any type of fluidised process is by-passing of gas in bubbles. The bubbles increase in size as they rise through the bed and eventually, in a bed which is not limited by walls, a large proportion of the gas passing up through a horizontal plane is contained in a few large bubbles. Hence, the most effective part of the bed is that below the region of substantial bubbles. On this hypothesis the plants which are magnified most successfully are those where the process is achieved in a shallow bed. Those which are difficult use deep beds in the laboratory equipment: in such equipment the bubbles cannot get larger than the diameter of the reactor and there is substantial showering of the solid through the bubbles: this behaviour differs in the larger plant unless special means are used.

The decrease in marginal effectiveness with increase in the depth of a single bed is shown by figures derived from plant results giving % H_2S removal under conditions of high space velocity.

		300°C	340°C	350°C
Bed depth:	12 in.	59	63.5	68
	15 in.	63	66.5	70
	17 in.	65.5	68	71

Attempts were made to relate the size of bubble with the surge indicated on the manometer showing pressure drop across a fluidised bed. Bubble size was estimated from flash photographs of the top surface of the bed. It was shown that the immersion of a baffle made of horizontal mesh grids diminished the pulsation amplitude in a bed and made the emerging bubbles smaller.

The use of bed baffles has been reported by a number of people. A horizontal mesh system was tried in the pilot plant, but it raised the minimum fluidising velocity and for that reason had to be rejected. The particle size, the particle size range and the gas properties affect the rate of bubble growth. There were no opportunities to investigate these variables on the pilot plant.

ACKNOWLEDGMENTS

Work reported here was carried out at the Appleby-Frodingham Steel Co. Acknowledgment is hereby made to the management. Many erstwhile colleagues in Frodingham Research Department are thanked for their friendly co-operation.

REFERENCES

[1] Reeve, L. *J. Inst. Fuel*, 1958, **31**, 319.
[2] Williams, T. H. *Coke & Gas*, 1954, **16**, 61.
[3] Gregory, S. A. *J. Appl. Chem.*, 1952, **2**, Supp. No. 1, 1.
[4] Schneider, R. G., Hoeven, H. van der, and Carter, A. J. "The Post-war Expansion of the U.K. Petroleum Industry", *J. Inst. Pet.*, 1953, p. 73. Hur, J. J., Deichler, J. K., and Worrell, G. R. *Oil & Gas J.*, 1956, October 29, 105.
[5] Patent applied for.
[6] Danckwerts, P. V., Jenkins, J. W., and Place, G. *Chem. Eng. Sci.*, 1954, **3**, 26.

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PILOT PLANT LABORATORY OF ESSO RESEARCH

Flexibility in operation and easy interchangeability of units are key features of this laboratory

IN the spacious grounds of a pleasant old mansion near Abingdon (Berkshire) the Esso organisation have built a Research Centre. This includes a large pilot-plant laboratory operated by a group made up of operating and technical staff. The work carried out in it varies considerably from time to time to meet the pressures of industrial research in a highly competitive industry.

Work at present being carried out by the staff covers a wide range of unit operations, both batch and continuous, as well as studies of an exploratory nature. The type of work includes: (1) the design and commissioning of new units; (2) exploratory studies on new processes and procedures; (3) operations to investigate scaling-up of a new process; and (4) the production of quantities of refinery products for research purposes. In these operations the volumes required are too large for production in the main research laboratories yet too small to warrant production at any of the Esso refineries in Europe. Typical requirements include dewaxing or hydrofining of petroleum fractions, or the preparation of gasoline components and middle distillates of various end points and distillation range. Apart from the many operators working in shifts to enable plant to run continuously and to maintain volume of operations required, staff is available for designing and commissioning units and for technical control purposes.

During a recent visit we saw in use batch and continuous distillation units, hydrofining equipment, a steam cracker, reactors for additive development and finishing (including clay treating) units. Flexibility is provided by using throughout similar types of metering pumps, heat exchangers and control equipment, and by providing an equipment pool of well-serviced control instruments, reactors, pumps, valves, industrial glassware and other ancillary equipment.

Batch and Continuous Stills

A set of four batch stills constructed largely in stainless steel have operating capacities ranging from 5 to 400 gal. The largest has a 14-ft column packed with ½-in. Lessing rings and Berl saddles and having a separating efficiency equivalent to 15 theoretical plates. An interesting feature is the availability of low-frequency induction heating on the largest still, the others being heated by electrical resistances. All but one of the units are now operating at atmospheric pressure, but the 12-gal. still is usable up to 250 psig and the remaining three are also suitable for vacuum work. The 6-ft-high column of the latter packed with $\frac{1}{16}$-in.-diameter Dixon rings of 100 mesh stainless steel is equivalent to 40-50 theoretical plates when operating at atmospheric pressure. The pressure still was in the course of being commissioned. It, too, has been designed to operate below ambient temperatures.

In addition to industrial glassware stills and continuous Oldershaw (sieve plate) columns for lower feed rates, there are two continuous vacuum stills in metal for feed rates up to 5 and 10 gph respectively. The former, which can be heated by electrical resistance and salt baths, can operate at pressure down to 5 mm Hg in the primary flash zone. Heating of the larger unit may be by electrical resistance, using fluidised sand and by low-frequency induction heating. Minimum pressure here is 40 mm Hg in the reboiler and the 12-ft column is packed with 1-in. ceramic Berl saddles. Both columns are used for assay work and their actual minimum overheads temperature is 200°F, maximum being 600-650°F.

Hydro-treating

Three stainless-steel hydro-treating units are available. All are semi-automatically controlled. The smallest, with an operating capacity of 0.1 gph, is capable of being used at pressures up to 1600 psig at 900°F with a maximum gas rate of 120 scfh. Figures for the largest are an operating capacity of 6 gph, maximum pressure 350 psig, maximum temperature 850°F and catalyst reactor volume of 4 gal. It can handle up to 300 scfh of treating gas, which can all be recycled. Hydrofining is widely applied for sulphur removal and for improving the stability of petroleum products.

Reactors and Catalyst Test Unit

Work on additives and petrochemical development is being carried out using a well-instrumented set of four metal and one glass stirred batch reactors. Three of the former are of 40 gal. operating capacity, made in stainless steel and capable of operating at small internal pressures (up to a maximum in one case of 35 psia) and at temperatures ranging up to 750°F. A circulating pump system is fitted for polymerisation studies, together with a continuous viscosity controller. Other batch reactions can be carried out in a

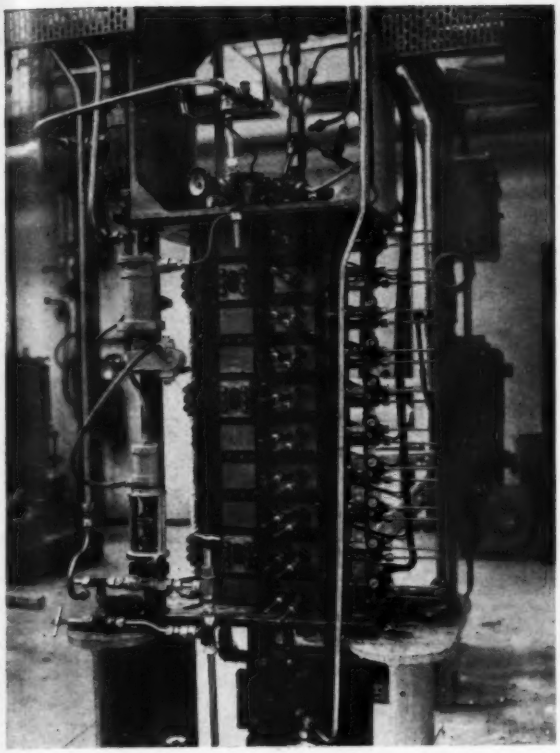

Fig. 1. Stacked stage extractor built up of Fenske plates applicable to a wide range of solvent extraction studies.

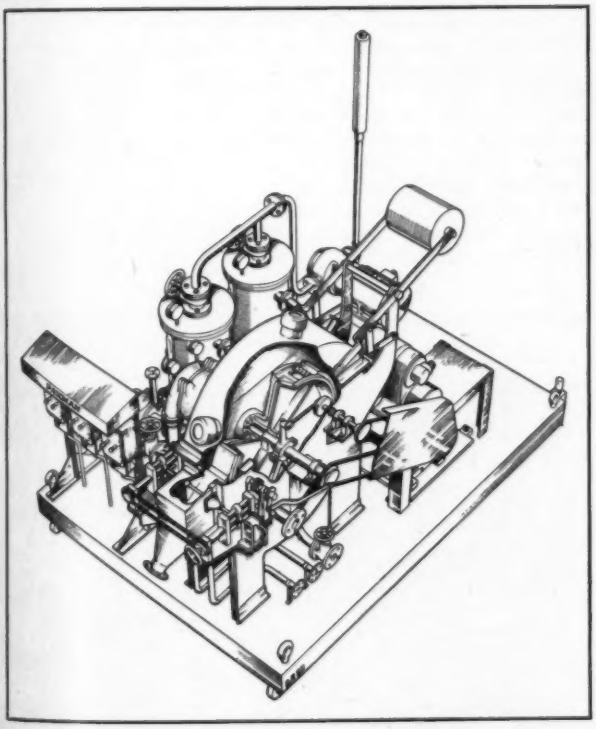

Fig. 2. Davey Paxman continuous rotary drum vacuum filter usable over a range of temperatures.

3-gal. glass reactor, with a paddle stirrer and reflux condenser equipped with gas injection and liquid transfer lines. However, there are also small reactors with controls for continuous work.

Steam Cracker

Feedstocks ranging from light naphthas to heavy gas oils may be treated in the pilot steam cracking unit to any desired severity. In the direct electrical heating system employed, the reaction coils themselves are the electrical resistance of the heating circuit. Versatility has recently been further increased by improvements to the product recovery system. Coil outlet pressure goes up to 25 psig and temperature to a maximum of 1700°F. Feed rate for the hydrocarbon is 3 gph. The gases pass through three condensers, the last of which operates down to −80°F. An interesting feature here and elsewhere is the use of p.v.c. bags for collecting gas samples, thus avoiding troubles with metal gas holders. Steam cracking is carried out to examine effects on the products of variations in feedstocks and in process variables.

Finishing Units

For final stages of treatment there are available standard types of centrifuge and plate and frame filters, together with the following more specialised items.

A 20-gal. dewaxer fitted with an anchor stirrer operates down to −20°F for low-temperature separations. It is used to remove wax from experimental lubricating oils to improve pour points and supplied with connections for liquid feed, gas purging and refluxing. For stripping dewaxed lubricating oils or other products, a 12-ft vacuum column is available packed with ¼-in. Lessing rings. This can take a feed of up to 20 gph, depending to a considerable extent on the nature of the material and the percentage of volatiles to be stripped off. Electronic control gear makes it possible to operate a small fixed-bed clay treatment unit either adiabatically or isothermally. This 1-l. unit is blanketed with oxygen-free nitrogen and handles 2 l./hr of fuel at up to 500°F and 500 psig. A second similar reactor is designed for a lower pressure and is less elaborately controlled. A fixed-bed copper sweetener is capable of dealing with feeds from naphtha to jet fuels; this can hold 600 g of catalyst and handle 2 l./hr of feed treated with 2 l./hr of gas at a pressure of 100 psig and temperature 300°F.

Fenske[1] plates have been built up into a stacked stage extractor which can be applied to solvent extraction studies using solvents with a wide range of volatilities. The distinctive feature about the Fenske plate is that flow is co-current within each stage, although it is counter-current over the column as a whole. The stack can be built up to 20 stages with sampling facilities and intermediate heating or cooling on each one; flow can be pulsed. Each stage is equal to a theoretical plate. It can operate at 400°F and 300 psig maximum with feed rates of 2 gal./hr for the continuous phase and half of this rate for the raffinate phase.

Shortly to be installed is a continuous rotary drum vacuum filter with a filtration area of 2.5 sq. ft, capable of carrying out filtration over a range of temperatures. The removal of the cake is continuous using a discharge knife which can be controlled by an automatic advance mechanism or can operate in a fixed position. The unit is mounted on a trolley. Throughout, flexibility in arrangement, connection and ancillary services has been a keynote so that the equipment is capable of being used economically for the large range of basic operations needed in petroleum development and exploratory research projects.

REFERENCE

[1] Fenske, M. R., and Long, R. B. "A Versatile Multi-stage Extraction Unit", *Chem. Eng. Prog.*, 1955, **51**, 4, 194.

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THE PRODUCTION OF ACETYLENE BY THE PARTIAL OXIDATION OF METHANE

by ING. C. CIRLOGANU

The chemistry of acetylene manufacture by the controlled combustion of methane and the various types of burners used are reviewed

ALTHOUGH autogenic welding is still a major consumer of acetylene, developments during the past ten years in countries with highly developed chemical industries have led to a situation where more than half the world output of acetylene is used for chemical manufacture. Thus, synthetic rubber based on chloroprene, acetaldehyde and vinyl chloride are now the main consumers of acetylene. In a country with a highly developed chemical industry, where more than 70% of the total production of acetylene may be used for chemical purposes, a typical analysis of its use is as follows[1]:

Welding	32%
Acetaldehyde and chlorinated hydrocarbons	26.2%
Neoprene	20.8%
Vinyl chloride	17.1%
Vinyl acetate	3.9%

As a result of the changing use of acetylene and the increased demand for it, a search has been made over a number of years for cheaper sources of acetylene. Such sources are the gaseous paraffin hydrocarbons, which are now available from the petroleum refineries and natural gas. Although the best yields are obtained from ethane, the most economic source at present is methane.

The reaction for the conversion of methane into acetylene is

$$2\ CH_4 \longrightarrow C_2H_2 + 3\ H_2 - 91\ \text{kcal.}$$

Depending on the way in which heat is supplied, there are three processes for the manufacture of acetylene from gases:

(a) the partial oxidation process in which the heat for the reaction is supplied by partial combustion of the hydrocarbon feed with oxygen;
(b) the "regenerative" process, in which the heat necessary for cracking is produced by the combustion of another material in special furnaces; and
(c) the "arc" process, in which the heat necessary for cracking is obtained from electrical discharges into the gas.

The fundamental principle of all these three methods is the rapid heating of the current of gas to very high reaction temperatures (above 1200°C), followed by rapid cooling after a very short reaction time (0.01-0.1 sec.) before any secondary reaction can diminish the yield of acetylene. By representing on a diagram (see Fig. 1) the variation in the free energy of formation for methane, ethane, ethylene and acetylene (reduced for comparison to the same number of carbon atoms) it is found that all the curves lie above the zero limit, at temperatures above 800°K. The gases are unstable above this temperature and may be split into free carbon and hydrogen. At a temperature above 1580°C the acetylene curve intersects the methane curve and continues below it. From this it is clear that beyond this temperature acetylene may be obtained from methane, and that acetylene is more stable at higher temperatures than the other hydrocarbons.

In the partial oxidation of methane, the mixture is brought to the minimum conversion temperature (1500°K) by burning part of the methane with oxygen—followed by rapid cooling and removal of the acetylene from the zone of the

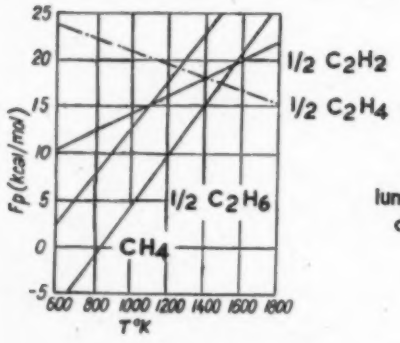

Fig. 1. Free energy of formation C_2H_2, CH_4, C_2H_4, C_2H_6, for comparison reduced to the same number of carbon atoms.

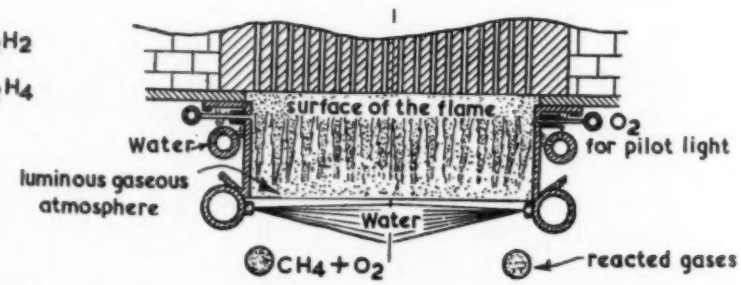

Fig. 2. The form of the flame in the partial oxidation of methane.

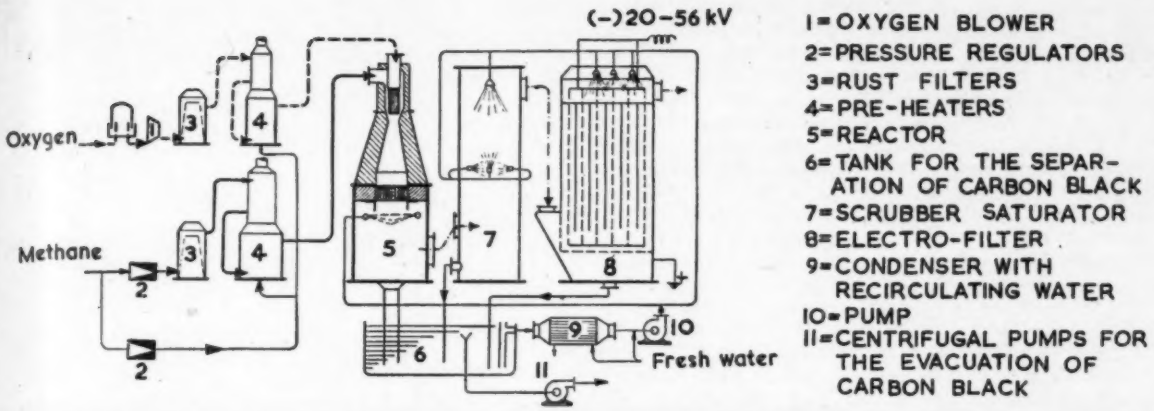

Fig. 3. Flow diagram of the partial oxidation of methane.

flame in a time much shorter than that necessary for its decomposition. In this way a continuous process is operated with good yields. The quantity of oxygen is much smaller (37-40% O_2) than the stoichiometrical amount, being enough to raise the temperature of the mixture from 700-800°K to the optimum temperature for conversion. The reaction takes place with a vigorous flame (Fig. 2), the main products of the reaction being water, CO_2, H_2, CO and C_2H_2.[3]

For reasons of thermal efficiency and in order to obtain a maximum yield of acetylene, it is preferable to work with preheated gases. From these considerations the overall reaction may be expressed by the approximation:

$$45\,CH_4 + 30.25\,O_2 \rightarrow 8\,C_2H_2 + 3.5\,CO_2 + 25.5\,CO + 54\,H_2 + 28\,H_2O.$$

In normal working approximately 0.7 mole of methane per mole of acetylene are present in the final gases: for instance, the preparation of 8 mole of acetylene from 51 mole of methane corresponds to an approximate consumption of 31% of methane for the chemical product,[4] i.e., 1.5 times more than in the arc process.

The mechanism of the reaction is as yet not well understood. It is assumed that the conversion of methane into acetylene proceeds through the formation of intermediate products such as formaldehyde and methanol.[15] Other investigations have shown that the partial oxidation takes place through the formation of radicals stable at temperatures above 1500°K (CH_2), the following scheme of oxidation and dehydrogenation being proposed:

Oxidation reaction chains
$$\begin{cases} CH_4 + O \rightarrow H_2O + CH_2 \\ CH_2 + O_2 \rightarrow CH_2O + O \\ CH_2O \rightarrow CO + H_2 \end{cases}$$

Dehydrogenation reactions
$$\begin{cases} 2\,CH_4 \rightarrow 2\,CH_2 + 4H \\ 2\,CH_2 \rightarrow C_2H_4 \rightarrow C_2H_2 + 2H \end{cases}$$

Water gas reaction $CO + H_2O \rightarrow CO_2 + H_2$

Dissociation of methane reaction $CH_4 \rightarrow C + 2H_2$

At one plant the process is carried out by feeding into a reactor of special construction methane and oxygen preheated to 400-600°C. The gases are mixed in the mixing zone of the reactor and then pass at high speed through a ceramic burner with channels 8 mm in diameter. Immediately below these jets a flame 160-220 mm long forms which is quenched by contact with water injected through atomiser jets. (Fig. 3.)

The gases formed, cooled to 70-80°C, pass through a saturator and thence into an electrostatic precipitator, in order to separate the fume black. Finally, freed from mechanical impurities, the gases pass through a section of the plant for concentrating and purifying the acetylene or into vessels for chemical conversion of the dilute gas, e.g., into acetone, and eventually acetaldehyde or vinyl chloride.

The methane supply is from the town gas grid and its pressure is reduced from 10-25 atm. to 1 atm. in a regulat-

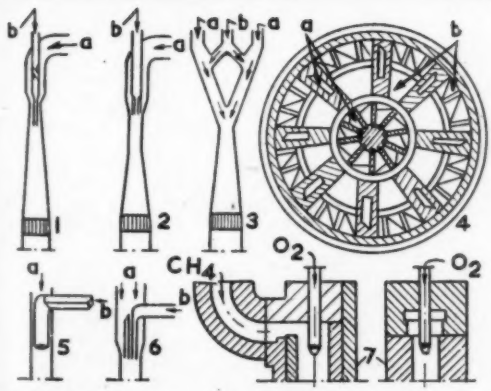

Fig. 4. Mixing devices. 4 is a cross-section through a turbulent mixer.

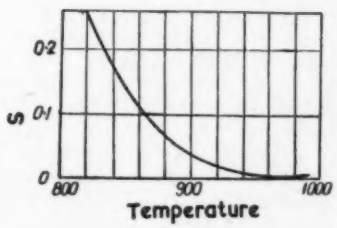

Fig. 5. Induction period as a function of temperature.

ing installation in two steps. The oxygen is drawn from a gasometer and compressed to 0.3 atm. After the flow of methane has been properly adjusted, the oxygen is metered by a proportional regulator at a rate corresponding to the optimum concentration of acetylene in the reaction products. Both streams then pass to the preheater.

The preheating of methane requires special attention, since there is a danger of its dissociating into carbon and hydrogen. Nevertheless, a series of investigations have revealed that when special nickel-free materials of construction are used for the preheaters (Sicromal 12, Thermax) hydrogen is not present in gases preheated below 600°C. The analysis was carried out by chromatography. For preheating methane and oxygen, radiation-convection type heaters with spiral tubes of refractory steel are used. The methane burners operate with turbulent flames and give a yield of 60-70%. The temperature of the reactor is measured in the diffuser.

With reactors of this type it is necessary that the gases be completely free from rust, ceramic impurities or powders. Partial blocking of the channels of the burner block (jets) is also very dangerous. The first group of impurities cause "auto-ignition", which leads to the extinction of the flame accompanied by an explosion in the mixing zone which can sometimes destroy the mixer. Channel blockages reduce the rate of flow of the methane-oxygen mixture below the rate of burning. The flame moves back into the diffuser, sometimes causing violent explosions which cause appreciable damage and therefore suspension of production. This phenomenon has been termed "re-ignition". Modern reactors operate at around 600°C, although some references in the literature recommend 450-500°C as the most economical temperature. The carbon black arising from the dissociation of methane is as dangerous as rust. It is known that particles of rust reduced to metallic iron during the preheating of the methane will oxidise in the presence of the oxygen and consequently during mixing will cause the combustible mixture to ignite and give rise to explosions. For safety the gases should be rendered quite free of mechanical impurities and rust by filtering, and the onset of methane dissociation should always be avoided.

Preheated methane and oxygen are passed into the mixer which forms the upper part of the reactor. In the early stages of development mixing presented many problems of the process. Some of the more representative types of mixer showing how the early difficulties were overcome are sketched in Fig. 4. After mixing, the gases are fed through the diffuser, which distributes them uniformly on the upper surface of the ceramic burner and through the jets. The gases then pass through the ceramic block (200-300 mm thick) at great speed and ignite underneath it in the "flame chamber" where their speed is considerably reduced and burn with a stable and uniform flame 150-200 mm long. Several jets of water under pressure intersect the flames. From the experience gained from the pilot and full-scale production, a number of points have emerged for the design of reactors which will work safely. Thus:

(1) The oxygen-methane mixture should approach perfect homogeneity as closely as possible. Turbulent mixers appear to be the most efficient for achieving this end.

(2) The distance between mixer and flame chamber must be traversed by the mixture in a much shorter time than the induction period of auto-ignition, especially when the preheating temperature is high (see Fig. 5).

(3) Finally, the speed in the channels of the ceramic burner must be sufficiently high to prevent the flame moving back into the diffuser.

In order to maintain a uniform and stable flame in the "flame-chamber" the mass rate of flow in the chamber must be equal to the rate of consumption in combustion.

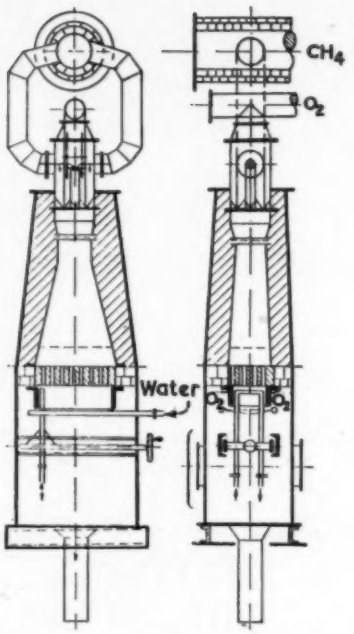

Fig. 6. Reactor for partial oxidation.

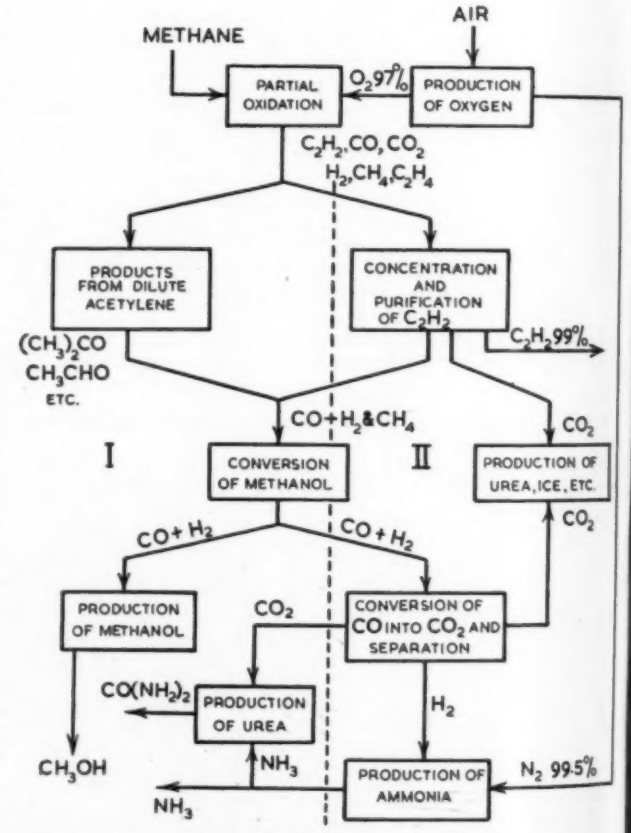

Fig. 7. Scheme for production of chemicals from acetylene obtained by partial oxidation of methane.

The arrangement of the burner and of the flame chamber, as well as the materials of construction, have been varied from one reactor to another, but generally the channels are distributed in the ceramic block over a rectangular area. In other designs the corners of the rectangle have been rounded off (with the flame chamber retaining its rectangular shape). Elliptic and even circular constructions also may be employed. The height of the channels (the thickness of the ceramic burner) is so chosen that the temperature of the upper part is the same as that of the gases (this feature makes it impossible for the heat from the flame chamber to be transmitted by conduction and thereby ignite the mixture in the diffuser). With a Mullite burner it has been shown experimentally that the temperature on the upper part does not rise more than 10°C above that of the gas mixture.

Between the lower part of the burner and the flame chamber oxygen is injected perpendicular to the axis of the channels through jets which provide the "pilot lights" necessary for starting the reaction (they are used only for lighting up). The flame chamber is in the form of a parallelepiped with the lateral walls either of ceramic material or refractory steel cooled on the outside with water. The flame formed in the interior is met by jets of water which "freeze" the equilibrium at the reaction temperature. The carbon black, formed by cracking, settles on the walls of the chamber and on the burner; it is removed by a scraper once every 3-4 hr (Fig. 6).

More recent constructions employ a completely metallic reactor[17] which has the advantage of longer operating periods without replacement of the ceramic burner and flame chamber. There is also no need for a scraper, since the carbon black is easily washed off the walls of the flame chamber by a film of water. This film must be continuous and thin and must not splash into the flame at the base. A major short-coming of the burners for partial oxidation is thus removed by this design, since the carbon black deposits which were a bugbear of the process, especially when working with hydrocarbons of more than one C atom or unsaturated hydrocarbons,[8] are eliminated continuously.

The water injected into the flame for freezing the equilibrium must be atomised so as to provide sufficient surface for evaporation and enough kinetic energy to enable it to penetrate into the gases. The cracked gas, saturated with water, leaves the reactor at a temperature of 70-80°C, with a composition lying between the limits given below.

C_2H_2 = 7-8%; CO = 25-26%; CO_2 = 3.5-4%;
C_2H_4 = 0.2-0.5%; CH_4 = 3-5%;
H_2 = 54-56%; N_2 = 2-3%.

Despite the water film, 1-2 g/m³ carbon black which are not entrained by the cooling water leave the reactor and must be removed whatever the subsequent process.

Various types of equipment have been used for the removal of this residual carbon black such as coke towers, bag filters and electrostatic precipitators.

In Rumania the latter have proved to be the cheapest and most effective means; consequently, most acetylene works in that country employ electroprecipitators. The removal of the carbon black takes place at 50-60°C on irrigated-type electrofilters. The gas saturated with water during scrubbing (over which water is deposited in the form of mist even in the electrofilter) is almost quantitatively freed from carbon black. Voltages from 30-50 kV are employed, the consumption of electrical energy being approximately 0.8 kWh/1000 m³ of filtered gas. The concentration of carbon black left in the gas is less than 10 mg/m³ and this does not interfere with even the most complex processes for concentration or chemical processing. Occasionally electrofilters are used in series.[8]

Acetylene installations are easily rendered automatic, the problems of automatic control being identified with the stabilising of the flame in the reactor. The fundamental principle of automation for these plants is that for a given preheating temperature (measured in the diffuser) a well-defined methane/oxygen ratio is necessary for reactor flame stability and optimum yield of acetylene. For automatic control of the reactor the exit temperatures of the methane oxygen preheaters are first regulated by means of pneumatic temperature regulators which control the rate of flow of methane. A magnetic analyser then determines the oxygen content and, therefore, the methane/oxygen ratio in the diffuser of the reactor. If this does not correspond to the predetermined optimum a mechanism is put into operation which adjusts the oxygen supply to correct the ratio.

Since this system takes into account the purity of the oxygen it is superior to the Askania proportional-type regulator. The installation is also provided with a safety system which stops the production process automatically and instantaneously if the rates of flow of water, methane or the oxygen fall or rise as compared with these normal values. The reactor "flame supervisor" and the oxygen analyser of the final gas function in the same way.

The factory controller receives light and sound signals if defects arise in the electrofilters, or if the pressure and temperature of the reactor vary beyond the allowable limits. The entire measuring, control and safety equipment is mounted on a control panel situated in a control house in charge of the process controller. Product control is carried out by continuous physical methods of analysis; acetylene is determined by infra-red absorption while the oxygen in the final gas (which gives the most important information about the running of the plant) is determined by thermomagnetic apparatus.[9] Carbon dioxide is also continuously analysed. The other components are checked from time to time with an Orsat apparatus, while a complete analysis (including higher acetylenes) is provided by chromatograph.

Two main routes are available for the subsequent processing of the gases produced by the partial oxidation of methane: direct conversion into chemicals at the concentration with which the acetylene leaves the reactor, or purification and concentration of the acetylene. Acetone is already being manufactured, while the production of acetaldehyde and vinyl chloride is still under development.

The best known process for direct conversion into chemicals is the production of acetone. The gases containing 7-8% of acetylene saturated with steam in the ratio 1 : 1 and then preheated to 400°C are passed over a zinc oxide catalyst in pellet form. The acetylene is converted into acetone with a yield greater than 70%, while the remaining gases may be utilised for the production of CH_3OH or NH_3 (Fig. 7).

In the past 10 years a few industrial processes have been developed for the purification and concentration of acetylene obtained by partial oxidation. Most of them are based upon absorption by selective solvents, but hypersorption processes are also being developed. However, absorption by a selective solvent remains the most usual method for the separation of acetylene from impurities or from secondary products. In these processes the cracked gases are brought into contact with a suitable solvent at a pressure up to 18 atm. in an absorption tower. The solvent (dimethylformamide, butyrolactone, methanol, ammonia, etc.) dissolves the acetylene, which is subsequently liberated by lowering the pressure and by heating.[3]

Dimethylformamide was among the first selective solvents to be used for the concentration of acetylene.[2, 3, 22] The gases are compressed to 12 atm., a stage for the separation of CO_2 is interposed and the gases are then brought into contact with the solvent. On lowering the pressure acetylene is liberated. The more soluble products, especially the higher acetylenes, are stripped off by steam and the solvent is recirculated. The consumption of solvent is ap-

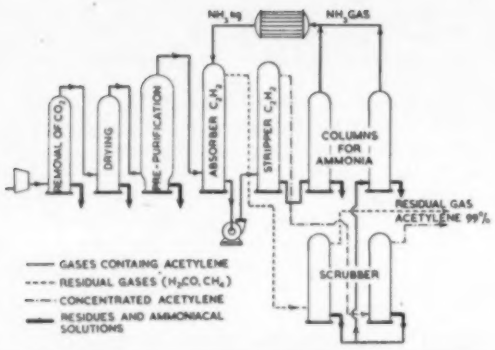

Fig. 8. Flow diagram of the purification and concentration of acetylene.

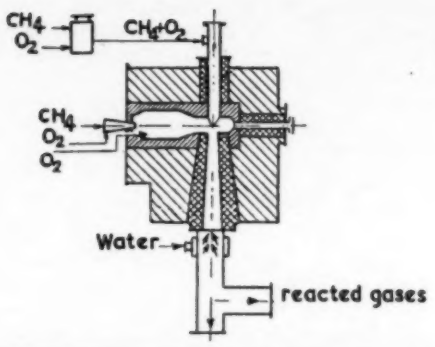

Fig. 9. Cross-sectional diagram of the pilot-scale turbulent burner developed by Grinenko.

proximately 4 t/t of acetylene.

In Italy methanol cooled to −70 to −80°C has been used as a solvent. The gases are compressed to 13 atm., carbon dioxide is removed by washing with ammoniacal solution and the absorption in methanol follows at −70 to −80°C from which an acetylene of 99%+ is separated, as before, by expansion and heating.[10, 11]

The gases remaining after the separation of the acetylene are cooled to −160°C in order to remove methane and the mixture of CO and H_2 is used for the production of methanol. The carbon dioxide separated from the ammoniacal solution is used in the manufacture of urea. (Fig. 7). A recent development in selective solvents processes employs ammonia at low temperature. This process is very cheap and very selective. At the temperature of liquefaction of ammonia (−34°C at atmospheric pressure) the solubility of acetylene is 20 times greater than in acetone which is the usual solvent for bottled acetylene. By contrast with other solvents, anhydrous ammonia dissolves only acetylene and its polymers. Ethylene is not absorbed.

In this process carbon dioxide is first of all removed by normal washing with amines. Then follows a drying stage, and the removal of aromatic hydrocarbons and of some higher acetylenes by chilled methanol. Finally the purified gases are absorbed in anhydrous ammonia at a temperature below −34°C and at atmospheric pressure. The absorption column contains a solution of acetylene and diacetylene in ammonia. Since the boiling point of ammonia lies between that of acetylene and diacetylene, the latter is removed at the end of the operation as a residue in the column employed for the separation of ammonia. The acetylene product has a purity better than 99.8%.[16, 20]

The gases evacuated from the absorber containing less than 1% of acetylene and composed mainly of carbon monoxide and hydrogen constitute a valuable raw material for ammonia or methanol. The process is very advantageous, since the solvent is very cheap, energy for compression is not required, very pure acetylene is obtained and the residual gases do not contain carbon dioxide (Fig. 8).

Hypersorption, which has recently given promising results in pilot plant, has not yet been employed in any industrial works. It offers the advantage of a considerably lower cost as compared with processes based upon selective solvents and yields acetylene with a purity better than 98%. A series of laboratory or pilot-plant investigations, some of which are highly original, shows that the process continues to be studied in order to improve its economics.

In the U.S.S.R. good results have been obtained with a reactor of the Grinenko type (Fig. 9) on a pilot scale, burning methane with oxygen, the flow of the mixture (methane-oxygen) being maintained at high turbulence. The flame is stabilised by the lateral introduction of supplementary oxygen preheated to 750-800°C. This "stabilisation oxygen" is heated by burning a small quantity of methane in an additional burner, and it represents 5-10% of the total consumption of oxygen. The final gas has practically the same composition as in the Sachsse process, the oxygen consumption being slightly lower.

The burning of methane and oxygen in a mixture rich in combustible gas has been carried out on a laboratory scale. The process takes place in an internal combustion engine, cooling being achieved by means of an expansion machine or a gas turbine. Another interesting line of approach is the production of acetylene from C_1-C_4 hydrocarbons, with a reduced ratio of oxygen/hydrocarbon which is now being investigated; the operating temperature is from 1200-1250°C and the pressure 6-60 mm Hg.[17] In the case where methane is being used, it is preferable to allow the reaction to proceed in the presence of silica; with the other olefinic and paraffinic hydrocarbons C_2-C_4, the reaction takes place without a catalyst. The possibilities of applying this process on an industrial scale are being studied and a reactor with a combustion surface is being constructed for this purpose.

The process has expanded since 1950, both in Europe and in America. In Rumania one acetylene works based on methane produces acetone as the final product. In Italy four large chemical works produce acetylene by partial oxidation and convert it into synthetic rubber, methanol, ammonia, nitrogenous fertilisers and urea. The Societe Belge de l'Azote (S.B.A.) has a plant at Marly and is building a large capacity plant in France for Houillerie du Bassin de Lorraine. In Germany, besides the group at Ludwigshafen, acetylene and ethylene are being produced by this process. In the U.S.A. two large plants use acetylene for acrylonitrile and other derivatives, while from the synthesis gas, ammonia and chemical fertilisers are being manufactured.

REFERENCES

[1] Fedorenko, P. N. *Khimicheskaya nauka i promyshlennost'*, 1956. No. 3. 337.
[2] Sachsse, H., and Bartholome, E. *Chem. Ing. Tech.*, 1954, No. 26. 245.
[3] Bartholome, E. Proceedings Fourth World Petroleum Congress. 1955. Sect IV/B Paper 3, Rome.
[4] BIOS, Final Report No. 877.
[5] Sherwood, P. *Chimie et Industrie*, 1956, No. 1, 78.
[6] Trevissoi, C., and Mazzei, I. *Metano*, 1956, 121.
[7] Pistor, E. *Chem. Ing. Tech.*, 1954, No. 4.
[8] Anon. *Chem. and Eng. News*, 1957, 76.
[9] Nemeth, A., and Cirloganu, C. *Revista de Chimie*, 1957, No. 2, 93.
[10] Paston, G. *Chem. Ing. Tech.*, 1955, Nos. 8/9, 485.
[11] Herbert, W. *Erdol und Kohle*, 1956, No. 2, 77.
[12] FIAT Final Report No. 988.
[13] Tesner, P. A. *Brit. Chem. Eng.*, 1958, No. 2, 72.
[14] Benedek, P., and Lazio A. *Magyar Chem. Fol.*, 1951, 57.
[15] Grinenko, B. S., *Khimia i Technologia Topliva*, 1956, 10.
[16] Anon. *Oil Gas J.*, June 1958, 125.
[17] Teutsumi, S. *Pet. Ref.*, March 1958, 169.
[18] Anon. *Petroleum Times*, 1957, 12, 1095.
[19] Salvi, G., and Fumare, A. *Metano-petrolio i nuove energie*, 1957, 2, 59.
[20] Anon. *Chem. Eng.*, 1957, 10, 144.
[21] Kosterhan, G. K. *Erdol und Kohle*, 1958, 6, 390.
[22] Anon. *V.D.D.*, No. 15961.

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RAPID PROGRESS AT WARREN SPRING LABORATORY

Adjoining the new town of Stevenage a new type of laboratory has been set up — free to carry out any process investigation to benefit the nation or a specific industry. What are its present interests?

THE Warren Spring Laboratory was officially opened on June 29, 1958,* by Lord Hailsham (now the Minister for Science) as an institution intended "to carry out process research and development over a wide field not limited to particular areas of technology". These wide terms of reference arose from the conviction of the D.S.I.R. Research Council that, when necessary, their research stations should change in function and objective to meet the needs of changing situations. We thought that it would be of interest to our readers to learn something of the development within the laboratory since the opening date. Naturally, no information is divulged on sponsored projects without the permission of the sponsors. However, within the general basic programme there have been appreciable developments in some sections, while in others new fields of work have opened up. It is some of these lines which form the basis for the following notes. We are indebted to the Director, Mr. S. H. Clarke, C.B.E., M.Sc., for granting facilities for our very interesting visits.

* The Warren Spring Laboratory "Open Days" will be held on July 22 and 25, 1960.

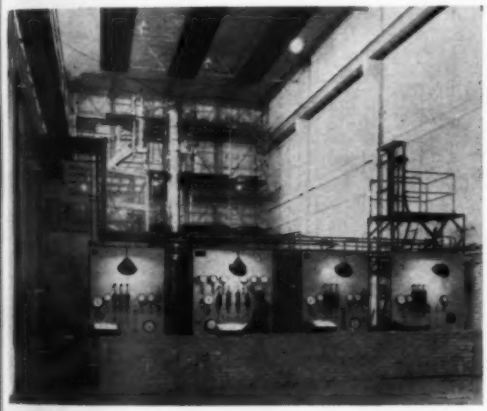

Fig. 1. Pilot-scale studies of the Fischer-Tropsch process.

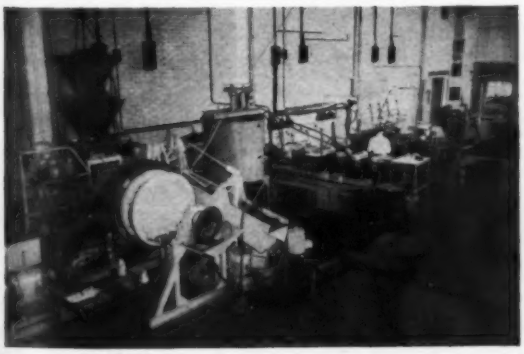

Fig. 2. Pilot-scale flotation plant.

Mineral Processing

Hydro-metallurgy

In this section chemical methods of treating ores are investigated. Because of the increasing usage of metals and the gradual depletion of ore reserves in the world, attention is now being directed to the extraction of metals from ores which were formerly considered to be too complex or low grade. Although many of these ores cannot be beneficiated by physical methods, the values can often be economically extracted by a combination of chemical and physical methods. One of the problems being investigated is the extraction of copper and nickel from a complex sulphide ore. Suitable recovery of the values can only be obtained by making a bulk sulphide concentrate. The process involves a sulphating roast of the sulphide concentrate to convert copper and nickel to water-soluble sulphates, while the iron sulphides are converted to insoluble iron oxide. For the separation and recovery of copper and nickel from the liquor obtained by leaching the calcine, a solvent extraction process is being considered. It has been found that a kerosene solution of naphthenic acid behaves as a cation exchanger and a certain degree of specificity can be achieved by adjusting the *p*H of the solution before extraction. Thus copper can be extracted at *p*H 6 and nickel at *p*H 8. This work will provide design data for pilot-plant operation.

A chloridisation process for extracting niobium from an ore containing about 2% of Nb_2O_5 is also being investigated. Previous workers have found that in this ore, which occurs at Mrima Hill in Kenya, the niobium values are so finely disseminated that they cannot be beneficiated by physical methods. The process being investigated involves pelletisation and then treatment with hydrogen chloride gas at elevated temperatures. Niobium distils off with the iron as a volatile chloride and can be recovered by condensation. For the process to be economic, the hydrogen chloride gas has to be recovered from the volatile chlorides and this creates problems which are also being investigated. It is thought that there are several advantages to be gained by using this gas rather than chlorine, which is the more usual reagent used in this type of process. Other methods being investigated for extracting niobium from the ore include leaching with ammonium fluoride with sulphuric acid.

Electrostatic Separation

The basic theory of the electrostatic separator is being studied on a roll-type machine employing corona charging of the mineral particles. At the same time, the effect of surface treatment of minerals is being investigated with a view to altering the surface conductivity which governs the

behaviour in a separator. The change in surface conductivity is examined by making an empirical measurement of the conductivity of fine-grained material (e.g., in a beach sand) in a standard cell.

More fundamental measurements of the change in surface conductivity will be made on polished sections of the mineral and the amount of reagent absorbed on the surface will be determined by examining the elliptical polarisation of plane-polarised light reflected from the surface. With this method, changes in optical thickness of the absorbed layer of as little as 1 Å can be detected.

Additive Grinding

In the same department research is being carried out on the effects produced by small quantities of reagent additions in grinding processes. Generally, it is claimed that with suitable combinations of additive and ore the power input to a mill can be reduced by as much as 30%, and in exceptional cases substantially greater savings have been claimed. The mechanisms by which such improvements are achieved are being investigated, and it is hoped that the controlling factors, after identification, will be applicable to full-scale grinding circuits.

Preliminary investigations are being carried out in a laboratory ring-ball mill on the effects of certain reagents on specific power consumption, rates of grinding, viscosities of the pulps and the characteristics of the products. The variables are pulp density, reagent quality, mill charge, operating temperature and loading of the mill. Tests so far have been limited to the use of a silicone reagent and a quartz rock.

Chemical Engineering

The chemical engineering now being undertaken in the laboratory is restricted to work on mass transfer and promoting dropwise condensation. Throughout this section there is great emphasis on mobility of apparatus, services, detection and measuring equipment, so that it is usual to see frames carrying panel boards and equipment on rollers, capable of being moved from one experiment to another.

A large part of the mass-transfer studies are intended to provide basic data for distillation and gas absorption. They arise from the recommendations of the joint report† by the two relevant trade associations and are additional to other allied programmes at universities. At the moment work is confined to sieve plates. Using air and water at ambient temperatures, bubbles are being photographed to determine bubble sizes, using as variables hole size, number of holes per unit area and liquid properties. In a 4-in.-square rectangular column bubble characteristics are being examined—measuring the gas-liquid interfacial area by the reflectivity of the foam, and using gamma rays for examining foam density. The relevant criterion for the mean bubble size in this case is the surface-volume mean. Little work has been done so far on the distribution of bubble size, but a 10-in.-square rectangular column is now being brought into use for further work using optical methods.

To measure the rate of flow of the liquid and foam across a plate, a unit will be employed which represents essentially a 6-in.-wide slice across a 3-ft-diameter sieve plate bounded by a weir and a down-comer pipe. Pulses of dye are recorded from the output of photocells. Electronic apparatus is available to generate a number of different wave forms for these pulses. Measurements are made at speed and it is necessary to use high-speed recorders. Again, gamma-ray equipment is being applied for measuring density. To determine the mass-transfer rate, oxygenated water is used as the feed and stripped with air. A polarographic dissolved oxygen recorder (developed by the Water Pollution Research Laboratory) monitors the feed and the overflow to determine the efficiency of oxygen removal.

In addition to these idealised systems without heat transfer, there is a distillation column, operating initially with a single plate, where actual distillations may be carried out.

A novel line of approach to these mass-transfer problems at the gas-liquid interface of very small bubbles is to use an analogue system of ion exchange resin beads. After allowing for the different physical properties of these beads and gas bubbles, useful information can be gained from measuring the rate of ion exchange. The beads are prepared with exchangeable hydrogen ions and thrown into a caustic solution. Using a glass electrode the graph of p_H against time is automatically plotted. The great advantage is that the particle size distribution and interfacial area of the system are controllable.

Process Developments

Elsewhere, design data have been derived for scaling up polymerisation vessels working at atmospheric pressure. Main attention here was given to the power requirements and the rheological data on the non-Newtonian viscous polymer systems. The experiments were carried out in a 1-gal. vessel using an anchor stirrer driven by a "floating" motor to which was attached a weight-loaded torque measuring device. From this it had proved possible to derive power relationships which, combined with earlier work on similar pots elsewhere, formed a basis for suggesting a scale-up correlation for predicting power requirements on a much larger pot.

The largest-scale project is the programme on evaluation of the Fischer-Tropsch process for the Ministry of Power which was taken over from the Fuel Research Station at Greenwich. Results from this have, of course, been supplied to the Wilson committee on chemicals from coal. On the pilot plant there is systematic investigation of the effects of altering the relevant variables. In addition, there are laboratory-scale studies of basic problems. An analogue has been set up using the much simpler reaction between ethylene and hydrogen bubbled through a slurry of nickel catalyst analysing the product gases by an infra-red absorption instrument. It is hoped that measurements of the kinetics of this simpler reaction will provide guidance on the more complex Fischer-Tropsch group of reactions. An early valuable result has been the discovery that for the ethylene/hydrogen reaction the rate was determined by the rate of solution of hydrogen in the slurry liquid. Tests are therefore being planned on the pilot plants, placing greater emphasis on better contacting between gas and liquid. In the laboratory a range of gas distributors is being tested, determining interfacial areas of the bubbler by light transmission using an obscuration method.

Fuel Cells

Sponsored by the National Research Development Corporation, preliminary reading on fuel cells started only last October and experiments in January. In this section an examination is being made of the fundamentals of reactions between the fuel gases and oxidising agents which might be present on electrode surfaces—chemisorbed oxygen, electrolytic ions, product gases. This is not primarily a design project to produce a cell or find optimum conditions for an existing cell. The whole direction of the effort is towards fundamental kinetics of the reactions indicated above for carbonaceous fuel gases such as methane or carbon monoxide in the presence of the electrode materials, which form a catalyst surface.

† Report of the Distillation Panel Recommending Some Basic Researches, May 1958. Association of British Chemical Manufacturers and British Chemical Plant Manufacturers Association.

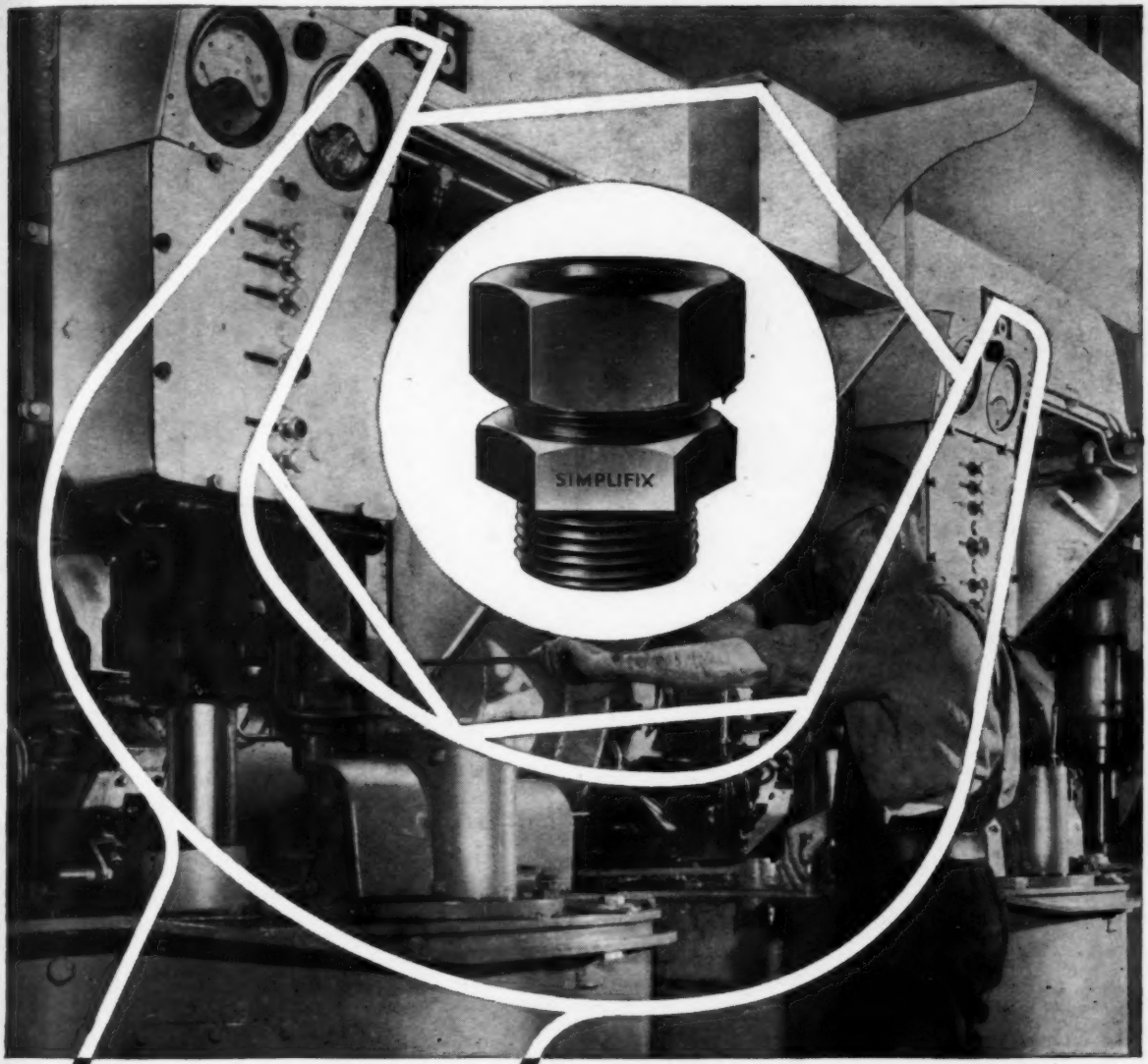

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Fig. 1. Impressive night view of Australian petroleum refinery.

OIL REFINING IN AUSTRALIA

by W. STRAUSS, M.E., M.Sc., Ph.D.*

BEFORE 1939 nearly all petrol and other refinery products were imported into Australia from other countries, crude oil imports accounting for only 10% of the total imported. For strategic and other reasons, as in the United Kingdom, the trend since the last war has been to import an increasing proportion of the demand as crude petroleum, and refine it close to where it will be consumed. By 1958 Australia was refining 93% of its motor spirit consumption, 39% of the aviation gasoline consumption, and had a surplus production of distillate, industrial diesel oil and furnace oil. In the last 10 years four major oil refineries have been built, two have been reconstructed or added to, and a fifth is due for completion by 1961. In addition, some major petrochemical developments are under way.

From Fig. 2, which shows a map of Australia with the populations of the states and their capital cities, it is seen that in most states more than half of the inhabitants live in the state capitals, which are on the coast. The general population density is not shown in the map. Most of the larger towns are near the state capitals; for example, the iron and steel manufacturing cities of Newcastle and Wollongong are less than 100 miles north and south of Sydney, while the city of Geelong, the second city in Victoria, is just over 40 miles from Melbourne. In Queensland the population is distributed chiefly in the rich coastal belt north and south of Brisbane. The people of West Australia, apart from those living in Perth, live mainly to the south of Perth in the south-west corner. Because of these population concentrations in and around the state capitals, the new refineries have been placed near them. The only state capital for which no refinery has so far been projected is Brisbane.

The three refineries in Sydney, serving New South Wales and Queensland, have a crude capacity of over 4 million tons a year and the two refineries at Altona and Geelong, both near Melbourne and serving Victoria and South Australia, have a yearly crude capacity of 4½ million tons. The Kwinana refinery near Perth is the largest in Australia, with a crude capacity of 3 million tons a year, while the projected Hallett's Cove refinery near Adelaide will have a yearly capacity of 1½ million tons. Kwinana has the advantage of being 3000 miles closer to the oil fields in the Persian Gulf, Indonesia and Borneo, as well as being in the state which is growing proportionally faster than the others.

Refineries and Ancillary Plant

Shell Refining (Australia) Pty. Ltd. operates two refineries. The larger of these is at Geelong, on Corio Bay, and came on stream in March, 1954. It has a capacity of 2,400,000 tons of crude a year, which is obtained from the Persian Gulf and British Borneo. Present plant includes atmospheric and vacuum distillation, fluid catalytic cracking, platforming, polymerisation, hydrodesulphurising and a new sulphuric acid plant, while a detergent alkylate plant is scheduled for completion by 1961. The refinery is connected to its Melbourne metropolitan distribution depot at Newport, 33 miles away, by an 8-in. pipeline.

The refinery at Clyde is placed far inland on Port Jackson, about half-way between Sydney and Parramatta. It first started operation in 1927, and recent modernisation, which included the installation of a platforming unit, has increased its capacity to 950,000 tons of crude a year. Other plant includes atmospheric and vacuum distillation plants, solvent and bitumen units and extensive storage and distri-

* Dr Strauss can be contacted through The Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2.

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bution facilities. Because of its situation, the new 47,000-ton tankers are unable to berth at the refinery and future developments will provide a suitable tanker berth and pipeline to the refinery.

Standard-Vacuum Refining Co. (Australia) Pty. Ltd only operates one refinery at present, at Altona on Port Phillip Bay, on the outskirts of Melbourne. The refinery first went on stream in 1949 but was greatly enlarged and extended a few years later, the refinery in its present form having been in operation since 1955. Its present capacity is 2,100,000 tons of crude a year, which comes from the Persian Gulf, Indonesia and Dutch New Guinea. The plant includes atmospheric and vacuum distillation, thermofor catalytic cracking, sovaforming and alkylation units, as well as desulphurising and sulphur-recovery units. It is the only refinery making aviation gasoline in Australia, and is designed to supply 50% of the demand. A carbon black plant already operates on the refinery by-products and some of the gases are sold to the Victorian Gas and Fuel Corporation to improve the calorific value of the Lurgi gas from the Yallourn field. A large petrochemicals plant is planned as an addition to the present refinery. The basic plant will produce ethylene and butadiene. The ethylene will be polymerised to polythene in a plant operated by Union Carbide, and to styrene and polystyrene in a plant operated by C.S.R. Chemicals (Australian Colonial Sugar & Distillers Ltd.) and Dow Chemicals. Synthetic rubber will also be made. Contracts for these plants have been awarded to the Fluor Corp. and Utah Construction.

A second refinery has been planned by Standard Vacuum for Hallett's Cove, about 20 miles from Adelaide, with an annual capacity of 1,550,000 tons crude.

B.P. Refining (Australia) Pty. Ltd. operates Australia's largest refinery at Kwinana, on Cockburn Sound, near Perth. The construction of this refinery was the greatest single commercial project ever to be undertaken in Western Australia. The plant came on stream in February, 1955, and consists of atmospheric and vacuum distillation units, fluid catalytic cracking, platforming, hydrofining and desulphurising units. The capacity for crude, which comes from the Persian Gulf, is 3 million tons a year.

TABLE I—Production and Consumption of Petroleum Products in Australia*

	Refinery Production ('000 gallons)	Consumption ('000 gallons)
Aviation gasoline	16,100	41,647
Motor spirit	983,113	1,059,710
Aviation turbine fuel	34,712	33,824
Lighting kerosene	12,670	57,023
Power kerosene	17,703	65,099
Automotive diesel oil	210,815	167,156
Industrial diesel oil	344,465	227,316
Furnace oil (inc. refinery fuel)	818,708	718,323
Lubricants	7,612	50,880
Solvents	2,819	21,280
Bitumen	52,221	47,740
Liquefied petroleum gas	3,729	3,729
Domestic gas (fuel oil equiv.)	6,787	6,787
TOTAL	2,511,454	2,500,514

* Year ended December 31, 1958.

TABLE II—Australian Exports of Petroleum Products, 1957–58*
(Quantities in '000 gall.)

July, 1957–June, 1958	New Zealand	Australian Territories	Aden, India Ceylon, Singapore	Other	Total
Motor and aviation spirit	48,597	353		632	49,582
Aviation turbine fuel	515			57	572
Kerosenes		215	5,557	371	6,143
Auto diesel oil	20,566	289	5,868	5,445	32,168
Ind. furnace oils	68,723	1,983	121,906	28,266	220,878
Others	2,164	524		1,005	3,693
TOTAL ('000 gal.)	140,565	3,364	133,331	35,776	313,036

* Including re-exports.

Fig. 2. Location of oil refineries in Australia.

Australian Oil Refining Pty. Ltd. supplies Caltex, and the Australian-owned Ampol Petroleum and H. C. Sleigh, the latter being minor shareholders. The refinery is at the Kurnell Peninsula on the shore of Botany Bay, just south of Sydney. Annual capacity is 2,050,000 tons of crude, which comes from Sumatra. This is to be increased to 3,500,000 by 1961. Plant includes two-stage distillation, fluid catalytic cracking, propane decarbonisation and polymerisation units.

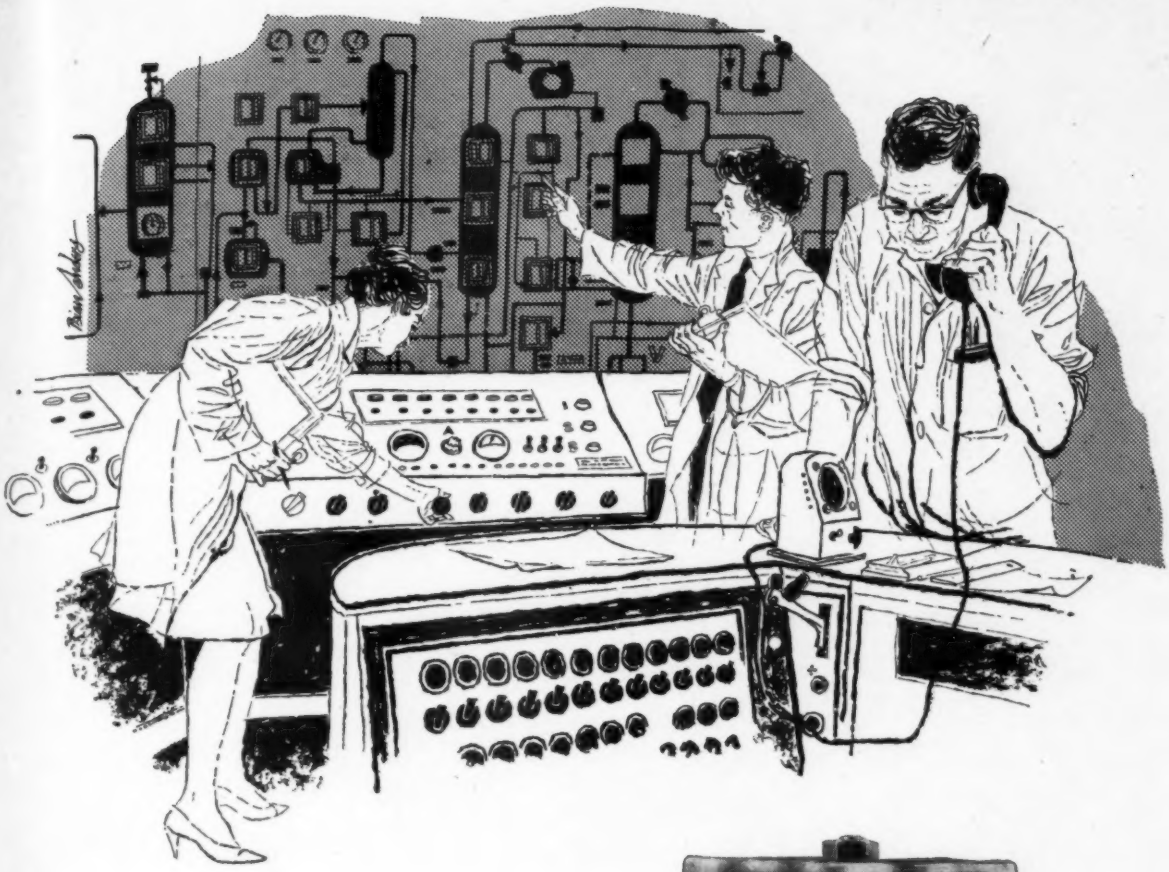
Bitumen & Oil Refineries (Australia) Ltd., a company in which the California Texas (Caltex) Corp. has an interest, operates refineries at Matraville, just south of Sydney, and at Hamilton (Queensland), with a combined annual capacity of 930,000 tons crude obtained from the Persian Gulf. Plant includes atmospheric and vacuum distillation units, platforming and unifining plant.

Products and their Distribution

Although the oil refineries are largely owned by non-Australian companies (B.P., Shell, Standard-Vacuum and California-Texas), petroleum products distribution is carried out by nine companies, several of which are Australian owned, and a tenth (Kangaroo Petroleum Co. Pty. Ltd.), also Australian owned, is about to commence distribution. The distribution companies are Shell, British Petroleum (which operate as competitors), Vacuum Oil, Atlantic Union (Esso), Caltex, Ampol Petroleum, H. C. Sleigh ("Golden Fleece"), Neptune and the Australian associate of the Compagnie Française des Petroles (Total Oil Products, Australia, Ltd.). Those marketing companies not directly connected with a refining company either have purchasing agreements with one of the refining companies, or, as is the case with Total Oil Products, obtain their complete requirements from abroad. No detailed data are available, but overall consumption and refinery production figures are given in Table I.

In recent years part of the Australian refinery production has been exported, chiefly to New Zealand, but also to Singapore, India, Ceylon and Aden. Some details for 1957-58 are given in Table II. However, a major refinery (crude annual capacity, 2 million tons) has been planned by Shell and financed in conjunction with the New Zealand investors on a 60/40 basis, and after 1964 New Zealand's imports will decrease.

ACKNOWLEDGMENT
The author acknowledges the assistance of the Petroleum Information Bureau (Australia), Melbourne, for its assistance with the statistical information.



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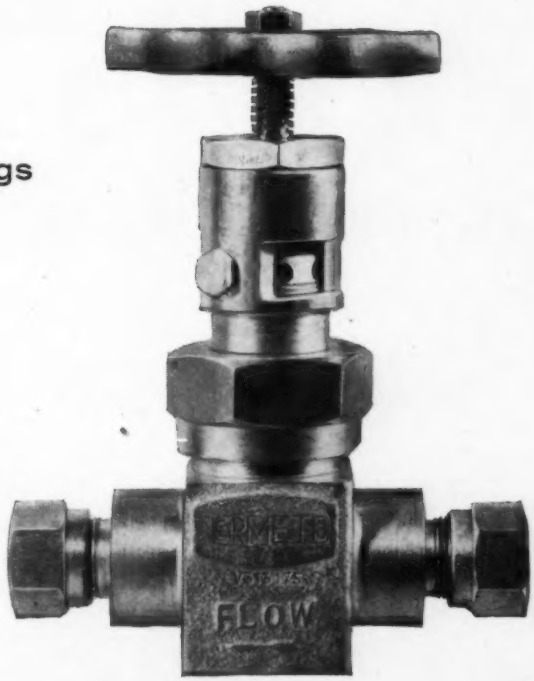

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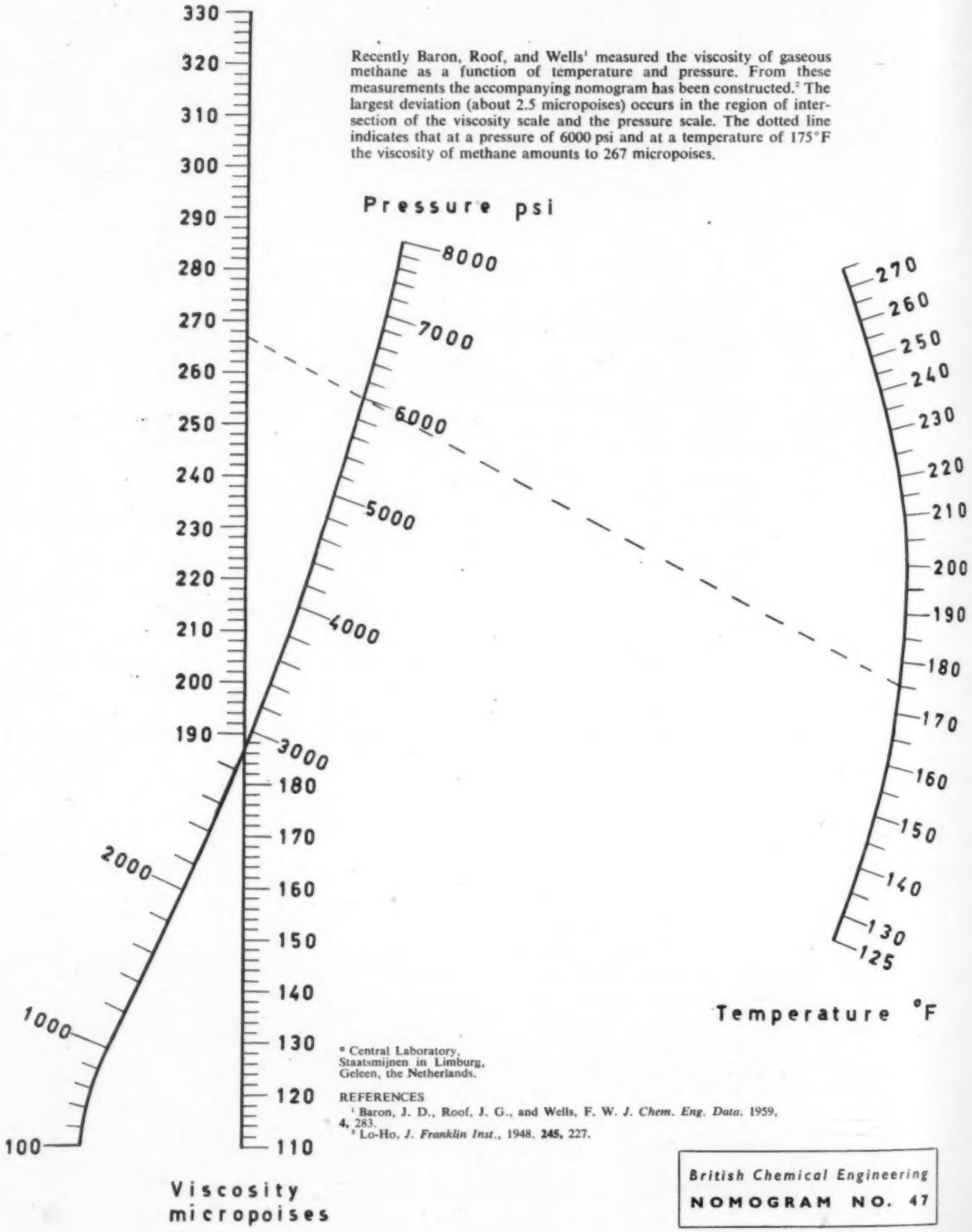
VISCOSITY OF GASEOUS METHANE

by A. M. P. TANS, Grad.M.I.Ch.E.*

Recently Baron, Roof, and Wells[1] measured the viscosity of gaseous methane as a function of temperature and pressure. From these measurements the accompanying nomogram has been constructed.[2] The largest deviation (about 2.5 micropoises) occurs in the region of intersection of the viscosity scale and the pressure scale. The dotted line indicates that at a pressure of 6000 psi and at a temperature of 175°F the viscosity of methane amounts to 267 micropoises.



* Central Laboratory, Staatsmijnen in Limburg, Geleen, the Netherlands.

REFERENCES

[1] Baron, J. D., Roof, J. G., and Wells, F. W. *J. Chem. Eng. Data*, 1959, **4**, 283.

[2] Lo-Ho, *J. Franklin Inst.*, 1948, **245**, 227.

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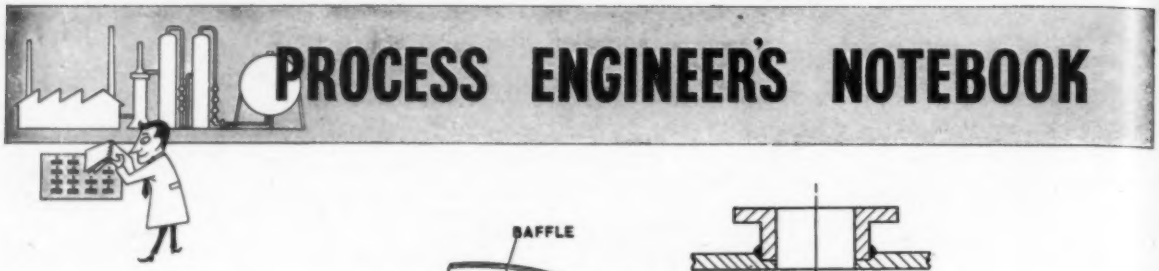
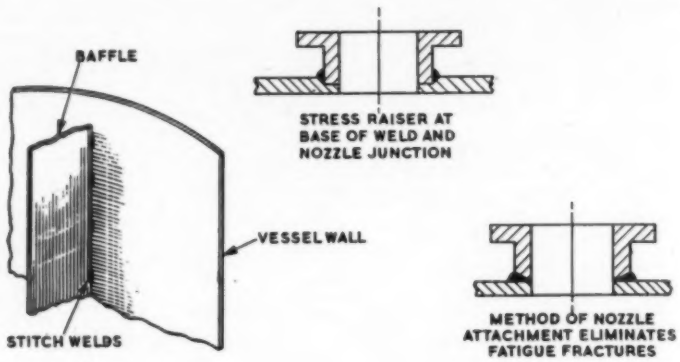


Sound Fabrication Practices


BAFFLE
VESSEL WALL
STITCH WELDS
STRESS RAISER AT BASE OF WELD AND NOZZLE JUNCTION
METHOD OF NOZZLE ATTACHMENT ELIMINATES FATIGUE FRACTURES

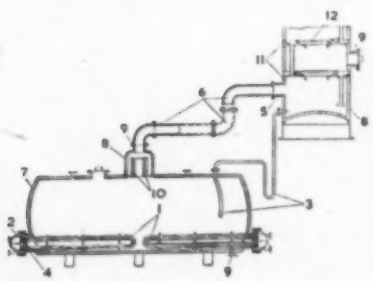
ECONOMIES IN DESIGN are often made to keep the cost of vessels low. When this is done, one must be sure that the corrosion resistance of the construction will not be impaired. An example of this was given in a recent paper,* the vessel being a sulphunator fabricated from Monel. This vessel was used at relatively high temperatures and was jacketed for steam heating; baffles were fitted to improve agitation, and for the sake of economy they were stitch-welded to the vessel walls. Unfortunately, the thermal gradients set up within the vessel caused the short weld-runs to crack. If the welds had cracked into the baffles little damage would have been caused. However, the cracks originated at the base of the weld and extended into the side wall, producing an unsafe operating condition. This occurrence would have been avoided by fillet welding along the entire length of the baffle and on both sides of it. Repairs made in this way proved entirely satisfactory.

Fatigue cracking also has to be avoided. The welding detail recommended by some codes for attaching a nozzle to an autoclave, whereby a recess is cut into the vessel plate, although usually satisfactory does suffer from the disadvantage of possessing a stress raiser at the base of the weld and the nozzle junction. In one instance cold solutions at 70°F were introduced into an autoclave at 700°F through a nozzle welded in this manner, producing marked cooling and contraction of the nozzle. It was not long before a fatigue failure occurred at the nozzle. The remedy is shown in the third diagram. Nozzles welded to the vessel in this way have given no trouble after eight years' service.

* Whitney, E. L. Paper 59-SA-58, A.S.M.E., June 14-18, Semi-annual Meeting.

Corrosion Protection at a Distillation Plant

THE FOLLOWING DESCRIBES a method of corrosion protection employed at a Russian plant for the continuous distillation of phenols.* A combination of materials was used including an austenitic steel (composition C 0.12, Si 0.80, Mn 2, S 0.03, P 0.035, Cr 17-20, Ni 8-11, Ti 0.80). This alloy was used for the heater tube nests (1) which have successfully withstood the action of the fluids distilled for more than two years. The headers (2) of the heaters are sealed on the inside with a layer of 10-15 mm thickness of dibasic cement. This layer breaks up and requires replacement after six to eight months.



The interior surfaces of the reboiler (7) are lined with acid-resistant bricks laid upon a layer of dibasic cement. After two years' operation this lining was still in good condition. The connecting piping, reflux line (3) and the reboiler overflow line have been replaced by stainless-steel tubing. In each case a life in excess of three years has been obtained. The mounting (4) of the tube nest and the joint (5) in the vapour line to the column were both lined with stainless-steel sheet, 3 mm thickness of the composition given above. This measure has extended the working life of these parts from four to five months to two years. The carbon-steel bends (6) in the vapour line did not last more than three to four months and were replaced by cast-iron fittings which so far have given a life of more than two years.

Protection of the inner surfaces of the column, where the conditions are severe, proved to be more difficult. Dibasic tiles have been used for the lower parts of the phenol and xylenol columns. Frequent observation of these linings, which have already been in use for about eight months on a phenol column, has shown that this type of lining, despite signs of fracture at a few places, may be a satisfactory method of combating corrosion in the columns. As to the other components of the plant, item (9) has a stainless-steel lining and so has the splash head (10) and shell (11). Item (12) is a C.I. plate.

* Ozerskii, G. M., and Markus, G. A. *Coke and Chemistry* (U.S.S.R.), 1959, **8**, 43.

Selection of Leak-proof Valves

IN A RECENT REPORT* the Electrical Inspectors refer to the problems of handling primary flash distillate in the gas industry. They state that:

"The use of low flashpoint oils such as primary flash distillate (p.f.d.) in the gas industry has led to interesting developments in leak-proof valves. Originally, doubts had been expressed on the performance of these valves, and it had been feared that there might be leakages which might give rise to flammable vapours, with consequent ignition from electrical or other causes. However, several types of valve have been brought into use for this service and it has been found that much better leak-proof performances can be obtained either by modification of the packing of the traditional type valve or by the use of completely different types. Where a valve is installed which will give this greatly improved performance, it has been found unnecessary to ask for a hooded enclosure drip tray and exhaust ventilation. To facilitate regular inspection and maintenance it is recommended that the valves should be placed in a readily accessible and adequately ventilated position and grouped where possible. The position of the cyclic valve might be determined to a large extent by the arrangement of the plant itself."

Thanks to the courtesy of the South Eastern Gas Board, we are able to give below details of the principal valves in use in the gas industry for handling light gasworks feedstocks.

For Use in Emergency

Totally-enclosed solenoid-operated isolating valves, supplied by the Magnetic Valve Co., are installed for distant control use in emergency. These valves were not developed specifically for use with light distillates.

For Use as Hand-operated Stop Valves or Control Valves

Cast-steel-bodied lubricated plug cocks, of "Audco" standard and "Hyperseal" types, are used as stop valves and for rate control. These valves were not developed specifically for use with light distillates, although a special lubricating grease is employed which is designed to resist the solvent action of the light distillate.

Cyclically-operated Valves

(1) The Humphreys & Glasgow quick-acting packed-gland type of valve used for cyclic operation on gas oil has been fitted with a modified Fluon-packed gland to render it suitable for use with light distillate.

(2) A bellows sealed valve, made by the Fisher Valve Co., with a Fluon-packed gland to serve temporarily in the event of failure of the bellows, has been successfully adapted for short-interval cyclic operation by reducing the valve stroke and thereby the movement of the bellows.

(3) A Hindle-Hamer gate valve with Fluon-packed gland, and Fluon sealing rings which are compressed against the wedge on the closing of the valves, and thereby provide an additional seal to that afforded by the metal-to-metal fit of the wedge against the valve seats, is now available. The valves are available with tapped and plugged bonnets, permitting the installation of "tell-tale" valves when necessary.

The particular development of the gate valve described above has been made with uses such as the handling of light gasworks feedstock in gas-making processes in mind and is supplied also in a form suitable for use as hand-operated stop valves or control valves.

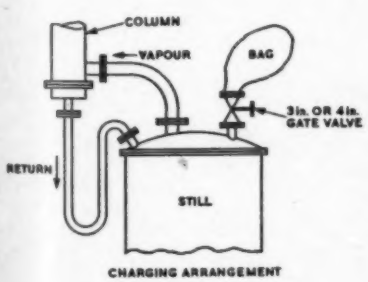
Line Isolating Valves for Use in Maintenance

Hindle-Hamer fluid saver spectacle valves are used for this purpose, although they are not specifically designed for it.

* Electrical Accidents and their Causes, 1958, H.M.S.O., 1959, 5s.

Method of Introducing Solids into a Vessel under Slight Pressure

THE FOLLOWING IS a method of introducing a small amount of solid material (powdered or granular) into a reactor or still operating at atmospheric pressure. In many batch processes, such as a distillation, which are carried out through a still or reactor, it is often necessary to add a small amount of a solid material such as an alkali for neutralising an acid catalyst before continuing the distillation. One way of doing this is to discontinue distillation, allow the still to cool, unbolt a manhole, charge the solid, then bolt up again before continuing the processing. The loss of time, waste of steam and general inconvenience are obvious. A simple way of carrying out this operation without interrupting the processing is as follows. Fit a large gate valve (3 in. to 4 in.) on a branch welded in the top of the vessel to be charged. Most large stills have spare branches of this size available. The solid powder to be charged is contained in a bag of reasonably impervious canvas (an Army kitbag is satisfactory). The mouth of the bag is provided with a simple flange for attaching it to the top of the gate valve. Lindaptor bolts or standard bolts with wing nuts may be used. The solid is added by opening the gate valve and gently shaking the solid down the bag, which is held in a horizontal position, into the still through the valve. When the addition is complete the valve is shut and the bag uncoupled. The amount of vapour which enters the bag from the still is not sufficient to cause more than a very small amount of condensation in the bag.



CHARGING ARRANGEMENT

E.K.M.

Contributions invited

THE EDITOR invites readers to submit, for possible publication in "Process Engineer's Notebook", notes on practical devices that have been elaborated on the job for improving the operation or increasing the safety of processes, or that have been extemporised in special circumstances. The contributions preferably should be of about 250-500 words, and be illustrated with a line diagram or sketch, or a photograph. A minimum of three guineas will be paid for each contribution used. They will be published anonymously or under the contributor's name, according to his wishes.

Book Reviews

Manufacture of Sulphuric Acid

Edited by W. W. Duecker and J. R. West
Chapman & Hall, London, 1959, 516 pp., 100s.

THIS is a composite work, various chapters being contributed by different authors, but skilfully edited into an easily readable book with, on the whole, a high degree of continuity. This is also the first comprehensive book on sulphuric acid to appear in the English language for a quarter of a century. It is doubly disappointing, therefore, to find the treatment of the subject rather superficial and elementary, a fault relieved only by extensive references.

After two introductory chapters reviewing the acid industry, mainly from the American point of view, and three others skipping lightly over the common raw materials, several chapters deal in a brief descriptive manner with the roasting of sulphide ores, and somewhat more adequately with the handling and burning of sulphur. The section on gas cleaning, cooling and drying is equally disappointing, barely succeeding to give more than a glimpse of the subject. The chamber process and similar systems are dealt with briefly next before coming to the best part of the book, namely two chapters on the contact process and catalysts in practical use. These treat the subject thoroughly and give well-documented information on the thermodynamics and, more noteworthy, on the kinetics of the SO_2 oxidation reaction. The following sections contain interesting and fairly comprehensive descriptions of common American design contact plants. The next few chapters briefly describe some of the processes for sulphuric acid recovery from inorganic and organic materials, acid concentration and the handling of acid plant waste gases, but the list is far from complete and there is little discussion of either the principles involved of their application in practice. The book finishes with some interesting general notes on the economics of the industry, industrial handling of sulphuric acid and relevant analytical procedures. An appendix with tabular and graphed data on the properties of sulphur and acid should prove valuable.

In conclusion, this book provides a useful general review of a wide and industrially important subject, but, except for one or two aspects, it does not contribute much to the fund of knowledge of sulphuric acid manufacture. One also feels that the authors have tended to concentrate on American practice and placed little emphasis on European developments. J.M.S.

Liquids and Liquid Mixtures

by J. S. Rowlinson
British Scientific Publications, London, 1959, 360 pp. 75s.

IN this book the author has attempted to find common ground for the treatment of both pure liquids and liquid mixtures. The first three chapters of the book are devoted to an account of the equilibrium properties of pure liquids and a development of methods for the calculation of the thermodynamic properties of a liquid in equilibrium with its vapour. The next three chapters are an account of the equilibrium properties of liquid mixtures primarily at low-vapour pressures. The last part contains a review of the development of theories of liquid mixtures from pure liquids, comparison between theory and experiment being made.

The book is primarily intended for chemists and physicists, but does provide a summary of the present knowledge of liquids which will be of use to the chemical engineer engaged in the more fundamental aspects of his profession. The first two parts of the book will also be useful to some design engineers as a source of information on the thermodynamic properties of fluids, particularly in view of the care taken by the author over this part of the presentation.

P. E. BARKER

Liquid Metal Heat Transfer Media

by S. S. Kutateladze, V. M. Borishanskii, I. I. Novikov and O. S. Fedynskii
Chapman & Hall, London, 1959, 150 pp., 180s.

THIS is a translation of the second supplement of the "Soviet Journal of Atomic Energy". It is essentially a survey of recent work, and contains a great deal of information presented in a terse, factual style, with relatively little attempt at critical analysis. A similar survey made in Britain in 1956 found over 200 papers worthy of mention; the book now under review, which was originally published in 1958, mentions only 81, but half are Russian in origin and likely to be unfamiliar in the West. The scope is comprehensive; it covers heat transfer in tubes, from plates and cylinders, by free convection, condensation and boiling, and there are chapters on physical properties, instrumentation, compatibility of materials and practical heat exchange equipment. Theoretical work is summarised, but most of the book is concerned with experimental results, presented graphically and compared with empirical equations.

The longest chapter is concerned with heat transfer in tubes; experimental data are presented in about 60 graphs of Nusselt number against Peclet number. Some interesting new Russian results are given, but only the better known American work is included, and some of this has apparently been derived second-hand from Lubarsky and Kaufman's survey. Discussion of the effect of "wetting" is brief and inconclusive; the work of Stromquist is referred to, but the subsequent investigation by Chelemer of effects due to gas entrainment has escaped attention.

The chapter on corrosion has been drawn almost entirely from previously published American work and it is doubtful whether its re-issue after a double translation is really justified. (The diagram which ornaments the dust jacket will be recognised as having appeared originally in the 1952 edition of the "Liquid Metals Handbook".)

The reproduction of the many graphs is excellent; the few photographs were poor in the original. Some minor errors, not present in the original, have crept into the translation; more serious is the duplication of Fig. 5.2 and the omission of Fig. 5.3. Some Western names suffer comically from double transliteration. The bibliography is incomprehensibly headed "Proceedings of the General Discussion on Heat Transfer"!

A. J. EDE

Werkstoff-Technik, Vol. 36.

Verlag Chemie G.m.b.H., Weinheim/Bergstrasse, 280 pp., D.M. 26.25, Members, D.M. 32.50 Non-members.

"WERKSTOFF-TECHNIK" is the title of Volume 36 of the Dechema Monographs and it completes the reports on the series of lectures delivered at the European Convention of Chemical Engineering and the ACHEMA Congress, 1958, which were held in Frankfurt (Main). The subjects dealt with in this volume may be divided into those which are concerned with the testing of materials and those which deal with the properties and applications of structural materials. In this connection, a distinction is made between metallic and non-metallic materials of construction.

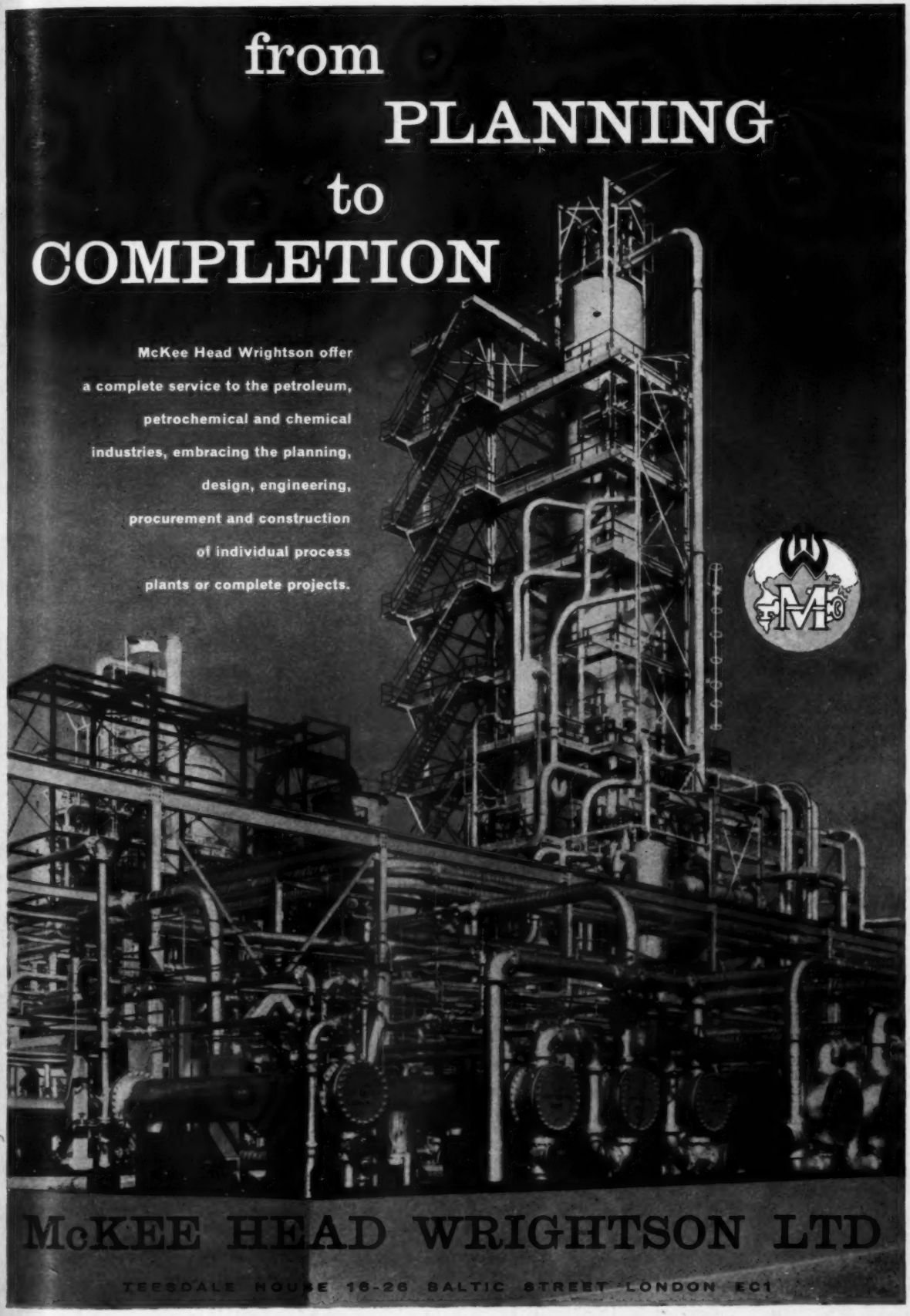
The fact that all these points of view had to be taken into account in arranging the present volume was due to the very diverse manner in which structural materials were dealt with during the ACHEMA Congress, 1958. The contributions on X-ray structural analysis, on surface treatments and on the structure of plastics, in addition to the traditional topics of tensile testing, chemical resistivity and the applications of structural materials, will be of particular interest to readers. Summaries of the papers in English and French are included.

Syntheses of Heterocyclic Compounds

Edited by A. L. Mndzhoian
Translated from Russian by A. E. Stubbs
Chapman & Hall, London, 1959, Vol. I, 71 pp., Vol. II, 84 pp., 48s.

THIS book contains directions for the synthesis of furan derivatives, compiled by the Armenian Academy of Sciences under the expert guidance of A. L. Mndzhoian. Furan compounds are used in such diverse fields as plastics (tetrahydrofuran in the preparation of adipic acid for nylon), medicine (nitrofurazon) and agriculture (the herbicide "Endothal", insecticide "Furethrin"). The ready availability of furfural, the aromatic character of the furan ring and the practical potentialities of the furan systems endow furan chemistry with increasing importance, so that the appearance of this book is most opportune. The book is a most valuable extension of "Organic Syntheses" for the benefit of the practising organic chemist and is wholly recommended. The publication of subsequent volumes in this series of "Syntheses of Heterocyclic Compounds" is promised and will be most welcome.

M.P.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Book Reviews (continued)

Das Trocknen
by Prof. Dr.-Ing. F. Kneule
Verlag H. R. Sauerlander & Co., Arrau and Frankfurt am Main, 1960, 358 pp., D.M. 45.

THIS book, which is the sixth in the series "Grundlagen der Chemischen Technik" and is written by the Director of the Department of Thermal Process Technology at the Technische Hochschule, München, covers the theoretical and practical aspects of the whole field of industrial drying.

The first part of the work consists of a comprehensive treatment of the theoretical aspects of the subject; topics such as diffusion, adsorption, capillarity, heat-transfer and mass-transfer being treated in considerable detail.

In the later parts of the work industrially-important types of drier are described and the performance of these appliances is studied in the light of the theoretical considerations presented earlier. Of particular interest are the sections devoted to laboratory drying apparatus and equipment for small-scale industrial applications.

The work is concluded with a detailed account of the various techniques available for psychrometric measurements and a considerable amount of design data is presented.

The book is profusely illustrated with diagrams and figures and contains numerous references to recent work on the subject. As an example of the care which has clearly been taken in presentation, the list of technical terms, together with their English equivalents and the corresponding symbols used in the text, which is presented at the front of the book may be mentioned.

In conclusion, Professor Kneule is to be congratulated on this work, which represents a contribution of major importance to the literature on the subject of drying, and it is considered that a volume should be on the bookshelf of all who are interested in the problems of industrial drying.

H. E. ROSE

Some Aspects of Analysis and Probability
Contributors: Irving Kaplansky, Edwin Hewitt, Marshall Hall, Jr., and Robert Fortet
Chapman & Hall, London, 1959, 243 pp., 72s.

THIS book is Volume IV of the "Surveys in Applied Mathematics", the series written as a joint project of the United States Office of Naval Research and "Applied Mechanics Reviews". These books are intended to summarise recent advances and to bring to light contributions which are not readily accessible in the more familiar languages. For this reason particular emphasis is laid on Russian contributions.

The book consists of the following four sections: "Functional Analysis", by Irving Kaplansky, "A Survey of Combinatorial Analysis", by Marshall Hall, Jr., "A Survey of Abstract Harmonic Analysis", by Edwin Hewitt, and "Recent Advances in Probability Theory", by Robert Fortet.

As a source of reference to advanced work and to recent contributions from Russia, this book will prove valuable, but only to those workers who have already specialised in the fields covered. However, it is the intention of the publishers and authors to summarise these fields in a concise manner, rather than to introduce the topics at an elementary level, and in this they have succeeded. The book can therefore be recommended to the specialist, but not to others.

N. H. LANGTON

Chemical Process Principles—Part II. Thermodynamics (2nd Edition)
by O. A. Hougen, K. M. Watson and R. A. Ragatz
Chapman & Hall, London, 1959, 110 pp., 78s.

THE first edition of this volume was published in 1947, and the material has now been expanded in the present edition. The most obvious additions are a considerably more detailed discussion of the thermodynamics of fluid flow and engine performance. A more detailed examination shows that the subject-matter of the first edition has been carefully revised, and a very full treatment of recently developed methods for calculating the thermodynamic properties of the solid, liquid and gaseous states is now available. An outstanding feature of the book is the excellent collection of model calculations taken from industrial processes. Even more important is the extensive tabulation of thermodynamic data which is contained in the book and which makes it a convenient reference source.

The book opens with an exposition of thermodynamic principles, and then deals with the properties of pure fluids, with particular reference to expansion and compression, fluid flow and the use of these principles in engines. A chapter on change of state then includes the principles of liquefaction, refrigeration and evaporation. The properties of solutions are then examined with particular emphasis on vapour-liquid equilibria. This is followed by a brief discussion of solubility and adsorption, and an even briefer examination of a few separation processes. The book ends by describing the calculation of chemical reaction equilibria.

The basic material contained in the book will be found in many places elsewhere. The particular value of the book, which may commend it to many engineers, is the extensive use of model calculations taken from practical examples of process design, and the use of correlations for estimating physical properties where these data are not readily available.

The Chemical Engineering Department of the University of Wisconsin, from which this book derives, has always made outstanding contributions to the science and teaching of chemical engineering, and the volumes on "Chemical Process Principles" form an important part of the literature. It is therefore comforting to find that this important work has undergone comparatively rapid revision in the light of experience and further research.

P. H. CALDERBANK

Annual Report 1958 of the European Federation of Chemical Engineering
Edited by the General Secretariat of the European Federation of Chemical Engineering, Frankfurt (Main) Office, Rheingau-Allee 25. Price to Members D.M. 15; Non-members D.M. 30.

THE Annual Report for 1958 of the European Federation of Chemical Engineering has been published in the form of a duplicated typescript of 233 pages. Part I of the Annual Report describes the development of the Federation which by the end of 1958 had been joined by 28 societies from 15 countries as members and by two societies from overseas countries as corresponding societies. The field of activity of the Federation, the means of work, the technical and scientific activities and the administration of the Federation are treated in detail in this section.

Part II contains the reports of the technical and scientific societies which have combined to form the European Federation of Chemical Engineering. They give an account of their work in the field of chemical technology, chemical engineering and process engineering.

Part III reviews the activity of European research institutes which are concerned with the field of chemical engineering and process engineering, chemical technology and chemical plant design. Particular thanks are due to the Federation for preparing this interesting review.

Shorter Notices.

BRITISH STANDARDS

B.S. 3189: 1959. Phosphate Treatment of Iron and Steel for Protection Against Corrosion, 4s. 6d.

THE present standard has been limited to treatments as used for the general purposes of industry. It does not cover the more specialised requirements of the Services, nor does it deal with phosphate passivation treatments by means of hot or cold solutions, which are sometimes known as "panel washes" and which consist essentially of phosphoric acid. No details are given of phosphate treatment as such. The specification sets out treatment requirements, methods of inspection and testing.

B.S. 3195: 1959. Methods for Sampling Liquid Petroleum Products in Bulk Storage, 4s. 6d.

THE methods described in this British Standard are technically identical with the corresponding methods of sampling specified by the Institute of Petroleum in Sections of I.P.51. They are intended for sampling liquid petroleum products contained in vertical fixed-roof tanks and horizontal cylindrical tanks, operating at or near atmospheric pressure.

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⅜″ mild steel plate valve casing, weighing 4 tons; in two pieces, a cylinder and a cone; dia. 9′7″ tapering to 6′2″ by 10′4¼″ long.

One of three stainless steel road tanks, for transporting phosphoric acid; each tank has three compartments and is jacketted with aluminium.

These two examples are typical of the large range of fabricated productions produced by Widnes Foundry and Engineering Co. Ltd., who offer a comprehensive service to industry, both in fabrication and foundry work.

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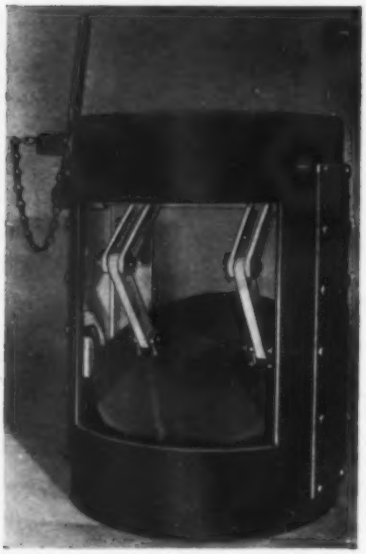
PLANT EQUIPMENT NEWS

Valve for Sealing Large Ducts



A valve designed originally for marine ventilation systems, which can now be supplied by Charton Weddle, has many potential applications in industry. These include its use in ducting systems, sections of which may require to be isolated at very short notice. They are suitable for installing in ductwork carrying air supplies to furnaces, particularly if occasions can be foreseen which may call for a sudden interruption of the air supply. The design provides easy maintenance, it is watertight and fireproof, and closure can be made almost instantaneously. Sizes range from 10 to 30 in. **Charlton Weddle & Co. Ltd., Manor Works, Newcastle upon Tyne, 1.**

BCE 7484 for further information

Counter

Production models are now available of a counter using transistorised Dekatron circuits of exceptional reliability housed in a completely sealed, robust industrial case. It may be employed for giving a running total or for batch counting applications where an output signal is needed at a predetermined number. It is possible to plug in straightforward decade divider units providing indication by means of a Dekatron. Any number up to six of these units may be used to indicate totals up to 999,999. The maximum counting speed is 10,000 pulses per sec. A batch divider unit may also be connected. This is a decade divider fitted with a ten-position switch to enable any predetermined number to be selected up to 99,999. The unit counts at speeds up to 8000 per sec.

When the counter is used for batch counting the coincidence unit-batch must be incorporated. The output signal can be used for deflecting chutes or trapdoors carrying the stream of articles being counted. Maximum batching rate is 4 batches per sec. A so-called paralysis sub-unit can be plugged in to prevent the counter from operating on a pulse following the previous one in a time shorter than the paralysis setting. It thus eliminates errors due to spurious operation on irregularities in the objects being counted. The paralysis times are adjustable from 0.2 to 200 milliseconds. **Airmec Ltd., High Wycombe, Bucks.**

BCE 7485 for further information

Suspended-bowl Vibratory Screens

The suspended bowl type of vibratory screen manufactured by Sinex has now been redesigned to enable users to fit new wire or nylon mesh screens themselves without having to obtain replacements from the maker. The previous design made use of a screen mounted on a beechwood ring, supplied as a complete assembly; in the latest model, however, the wire mesh is simply folded upwards round the edge of the bowl and held in position by a circular clamp. This development will make screen replacement a cheaper procedure and will eliminate the need for stocking a range of screen assemblies. **The Sinex Engineering Co. Ltd., North Feltham Trading Estate, Feltham, Middlesex.**

BCE 7486 for further information

Bag Filters for High Dust Burdens

A bag filter developed by Standard Filterbau Gesellschaft m.b.H., of Munster, is to be manufactured under licence in the United Kingdom by W. C. Holmes. The equipment, to be known as the Holmes-Retroflux bag filter, is particularly suitable for those applications where high dust burdens are encountered and/or where adhesive dusts have to be collected. It possesses an efficient and continuous method of cleaning the filter bags which ensures that large volumes can be handled with constant pressure drop and high collection efficiency. An efficiency in excess of 99% for all particles, including those of submicron size, can be guaranteed.

The dust-laden air entering the filter is distributed to the inside of the filter bags, the air and dust moving in the same direction. The tendency of the dust to settle by gravity is not impeded by air currents, as the air passes through the filter bags radially and the air velocity gradually diminishes to zero at their lower ends. The dust collected on the inner surface of the filter bags is continuously dislodged by the passage of high-velocity air jets through the fabric in the reverse direction to the main air stream. The dislodged dust falls by gravity to the worm conveyor or hopper below. The high-velocity jet system makes it possible to dispense with rapping or shaking mechanisms as well as separate compartments as encountered in other types of bag filter.

A major advantage over other bag filters is that each filter bag is continuously and efficiently cleaned over its entire surface area. One important result arising from the use of high-velocity cleaning air is that the filter resistance can be maintained at approximately half of a conventional bag filter without sacrifice in efficiency. An appreciable saving in power consumption is therefore achieved. **W. C. Holmes Ltd., Turnbridge, Huddersfield.**

BCE 7487 for further information

Electrodialytic Desalting Apparatus

A smaller-size unit is now available to produce up to 200 imp. gal. of potable water per 24 hr at a salt content of 600 ppm by electrodialytic desalting. Essential features of the unit are a stack of membranes, a 110-gal. batch tank, a transformer-rectifier, and an automatic acid-dosing device. The 18-gal. acid tank is sufficient for 100 days' continuous operation with seawater. There are also a maximum current switch-off, a minimum current switch-off and starting and re-set switches.

All parts coming into contact with liquid are made of plastic or plastic- and rubber-lined steel. The pumps are made of P.V.C. and the framework is galvanised. Power consumption is approximately 400-1000 watt, depending on the nature of the feedwater and the production required. Acid consumption is approximately 18 gal. 30% HCl or H_2SO_4 per 100 days.

Overall dimensions are 2 ft 8 in. × 2 ft × 3 ft 4 in., shipping weight approximately 1100 lb., operational weight approximately 2200 lb. To install the

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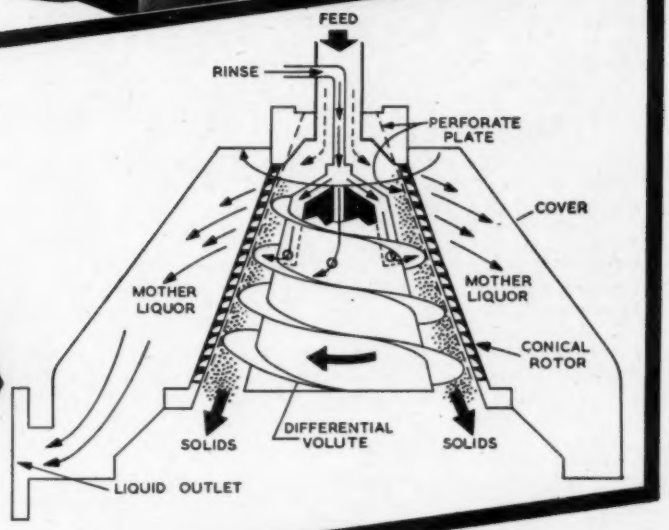

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PLANT EQUIPMENT NEWS

unit it is necessary to provide the following services: earth connection to the frame, a ½-in. feedwater supply at a pressure of approximately 10 m. w.g., a ½-in. drinking water discharge, a 1-in. drain, and a ½-in. gas purge. The unit can be equipped with a conductivity relay to regulate the salt content of feed and drinking water, automatic time switches to switch off the unit during week-ends, safety devices to cut out the unit if the acid tank is not refilled at the required intervals, and other automatic devices. **Bronswerk, P.O. Box 28, Amersfoort, Holland.**

BCE 7488 for further information

Polypropylene Sheet

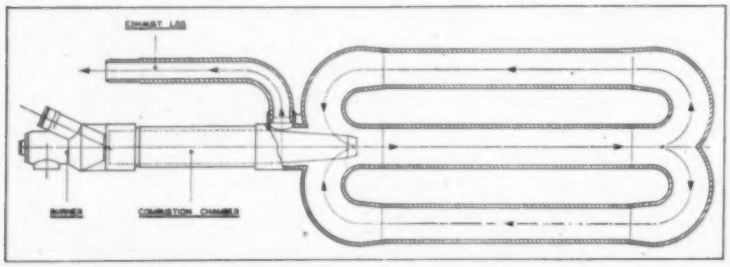
Polypropylene is a comparatively new material, and its extrusion in a range of sheet gauges from 0.020 in. up to ⅛ in. by Telcon considerably extends the field of application for thermoplastic sheet. Despite the fact that it is the lightest of all current thermoplastics, polypropylene has remarkable stiffness, surface hardness and abrasion resistance, in which respects it is superior to either high- or low-density polythene. The chemical and electrical properties are either equal to or better than those of polythene, but it has a slightly lower impact strength.

The very high melting point of polypropylene gives a material that may be fabricated by conventional means and yet may be sterilised by repeated immersion in boiling water. In fact, provided it is not under internal or external stress, it may be used at temperatures up to 150°C. Furthermore, it does not suffer the bugbear of environmental stress cracking and may be used with complete safety in contact with soaps and detergents. Like polythene, it will gradually oxidise and suffer thermal degradation as a result of prolonged exposure to the atmosphere at elevated temperatures, but if suitably protected by the inclusion of carbon black it may be safely exposed to ultra-violet light for long periods. Like polythene, the material will burn if ignited. Applications for the sheet include corrosion-resistant chemical plant, and ducting for fume extraction and heating and ventilating installations. **The Telegraph Construction & Maintenance Co. Ltd., Mercury House, Theobalds Road, London, W.C.1.**

BCE 7489 for further information

"Jetubes" Radiant Tube Elements

In high recirculation radiant tube heat-transfer elements, known as Jetubes, a gas and air mixture is burned in a refractory-lined section of the tube. The products of combustion which leave this chamber through a nozzle at high velocity, entrain the hot gases already recirculating in the body of the tube and so build up recirculation.



The system has a number of advantages. The recirculating gases protect the tube from the high-temperature gases leaving the nozzle and thereby avoid troublesome hot spots. The gas velocity in the tube is many times that which would be obtained with single-pass operation so that heat transfer rates are very high. The high turbulence gives intimate mixing—another factor contributing to the elimination of hot spots. In addition to high rates of heat transmission, there is very little temperature drop over the whole element; hence heating is rapid and uniform, and the Jetube can be operated with a comparatively low-temperature lead. Additional efficiency may be obtained by fitting a small recuperator to each tube.

These tubes are the heart of the first vertical plant now in operation at the Velindre Works of the Steel Co. of Wales Ltd. The Jetube system can be used in many different forms and sizes to suit requirements.

An important application is in large air heaters, for example, at plants requiring treatment of a product in a heated air stream. For applications of this kind the air passes through heat exchangers consisting of banks of oil-fired Jetubes. Temperatures up to 800°C are readily obtained. Another application uses horizontal oil-fired Jetubes for heating a product on a mattress conveyor, thus giving a "radiant roof". **The Incandescent Heat Co. Ltd., Smethwick, Birmingham.**

BCE 7490 for further information

Sack or Drum Manipulation

This equipment has been designed to lift and tip sacks, drums, bins, etc., and can be moved close to the receptacle into which discharge is to be made. Two lifting arms operated by independent hydraulic rams lift and tip the hopper holding the container. The drive is by a 3-hp 1425-rpm electric motor, coupled direct to a hydraulic pump.

The machine, which weighs approx. 5 cwt, can handle up to 6 cwt and will discharge at heights from 3-8 ft. The unit can be supplied on wheels. The steel hopper, equipped with valve, is bolted to the main frame. Quick-release screw clamps are provided for holding the drum, bin or carton in position, and for sacks a special retractable steel claw is provided. Pre-lubricated self-aligning bearings are used throughout and very little maintenance is required. The unit is of robust construction, silent in operation and capable of continuous 24-hour duty. **Russell Constructions Ltd., Russell House, Adam Street, London, W.C.2.**

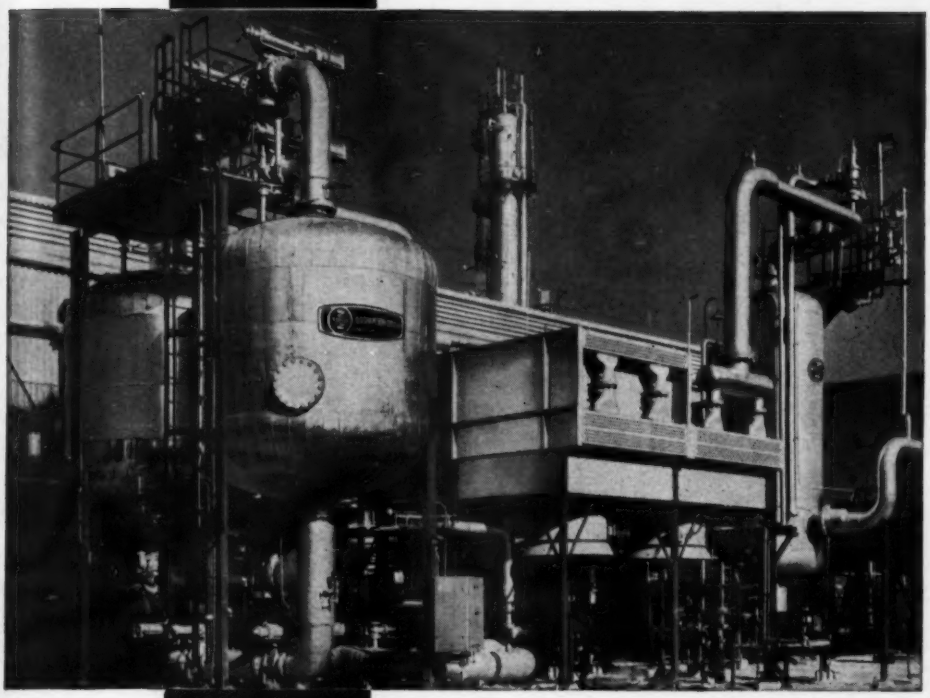
BCE 7491 for further information

"Cubitainers"

Since the "Cubitainer" was first introduced to the British market a little over a year ago by Iridon Ltd. (one of the Commercial Plastics Group of Companies), much research has been carried out by the company to improve upon the working performance of the original pack. The three sizes that are currently available are 5 gal., 1 gal. and 1 qt and it is planned that the next size will be a ½ gal.

This new product is primarily a disposable pack for the one-way transportation of liquids, although it can be used for powders and semi-solids. "Cubitainers" are extremely light in weight compared with more conventional forms of containers, and are a quarter the weight of steel drums and five times lighter than glass containers. Being non-returnable, expensive cleaning and reclaiming plant is unnecessary and the cost of paper work involved in returnables is also eliminated. The cube shape makes for economical stacking and transportation.

Birlec Process Gas Dryers



Birlec power former dryer installation at the Whitegate Refinery of the Irish Refinery Company Limited showing, from left to right, dual adsorber pressure vessels, air-cooled heat exchanger and scrubber tower.

at Whitegate Refinery

In the relatively new power former process for fuel enrichment, dry flue gas is circulated through catalytic reactors during the off-stream cycle. For the Irish Refinery Company Limited at Whitegate, Birlec has built a special dual adsorber dryer for the continuous removal of 240 lbs. of water per hour from the purging circuit. A flow of 18,100 c.f.m. is handled at 100 p.s.i.g. and the dryer maintains an outlet H_2O concentration of 15 p.p.m. (–40°F dewpoint). The plant, which is 20 ft. high and contains 10 tons of desiccant in each pressure vessel, also incorporates a scrubber and a filter for the flue gas and is designed to eliminate the use of cooling water.

An important part of Birlec's service to the petroleum and chemical industries is the design and fabrication of adsorption dryers that guarantee performance in process applications. Additionally, Birlec has wide experience of drying by refrigeration, absorption and compression. During 20 years in the field, Birlec has acquired unrivalled knowledge of costs, capacities, efficiencies, impurities and load fluctuations, and is particularly well equipped for advising on specialist problems with a technical content.

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PLANT EQUIPMENT NEWS

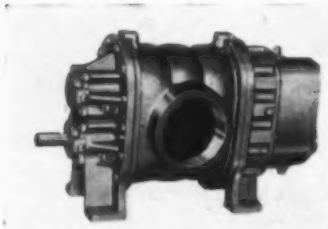
Existing filling equipment can easily be adapted and "Cubitainers" may be filled either by weight or volume. Heat sealing is the recommended method of closure and a simple tool consisting of a frame to hold the "Cubitainer" and a sealing iron is available, while more elaborate heat sealers, such as the foot-operated, jaw-type sealer, with thermostat and thermometer, can be purchased.

Re-closure of "Cubitainers" after use can be achieved by simple slide clips and these give good temporary sealing and reasonable airtightness. A special dispensing device is also available which consists of a plastic probe attached to a unique clamp by a flexible tube. This is inserted through the outer and inner containers and allows a controlled flow with no wastage of the product. **Iridon Ltd., 75 Grosvenor Street, London, W.1.**

BCE 7492 for further information

Small Vacuum Blowers

A range of small-volume vacuum blowers now being offered by Roots-Connersville are designed for capacities from 30 to 1000 cfm and vacuum to 20 in. Hg. in single-stage application; these units may be compounded for vacuum service over 20 in. Hg. Major features of the design include elimination of internal valves, absence of contact between moving parts, virtual freedom from maintenance, maximum efficiency of rotor design and operating speeds and minimum sealing-water requirements. At reduced vacua, these units may be operated without



sealing water depending upon the specific application. This range of vacuum blowers has more than 40 standard sizes. Larger, single-stage Roots cycloidal units are rated up to 13,500 cfm at vacuums to 22 in. Hg. Compound units deliver as much as 15,000 cfm at 27 in. Hg. **Roots-Connersville, Connersville, Indiana.**

BCE 7493 for further information

Gearbox for Mixing Duties

In large mixing tanks and closed pressure vessels it is usually necessary to have bottom bearings on shafts longer than 15 ft with the attendant problems of certain and adequate lubrication and maintenance. The new range of Agidrive gearboxes introduced by Chemical Equipment Engineering Ltd. are specially designed for agitation work and allow for overhung shafts of up to 20 to 25 ft length free of whip and without any bottom bearing. The elimination of a bottom bearing with such great shaft length has been achieved by the much wider spacing of the bearings inside the box than is usual in gearboxes of equivalent size. The standard output shaft is specially designed to promote rigidity, being 30 to 50% larger than the equivalent conventional worm gearbox. If desired, the standard shaft sizes can be increased without major modification to the internal design and working parts.

A wide range of agitator speeds may be obtained between 16 and 400 rpm by the simple, quick and effective use of pick-off gears similar to the long-established method used for lathe change wheels. Power of up to 100 hp can be transmitted safely and continuously. The units are fitted with either mechanical seals or stuffing boxes. The dry-well construction of the final drive shaft allows for perfect lubrication but prevents oil getting down the shaft. A flush-through greasing device ensures complete lubrication of the bearings. The high mechanical efficiency of the gears permits cooling without the need for external fins, which means that the outer casing has a streamlined appearance and reduces the collection of dust and dirt encountered in the majority of applicable working conditions. Details of the six Agidrive gearbox units available giving a range from 1 to 100 hp may be had on request to **Chemical Equipment Engineering Ltd., Macclesfield, Cheshire.**

BCE 7494 for further information

Split Mechanical Seal

A new split mechanical seal, the Sectaflex, is said to solve the problem of providing a rotary seal the wearing parts of which can be simply and quickly replaced without stripping down the shaft. Replacement of worn parts only entails removing a few screws, taking out the old parts and inserting new ones. Precision manufacture of the components ensures an extremely low leakage rate of the order of only a few c.c. per hour. Sectaflex mechanical seals can be used at pressures up to 100 psig and temperatures up to 300°F, provided the vapour pressure at the operating temperature of the fluid being handled is less than atmospheric. They can, therefore, be used on all types of rotary shaft equipment—pumps, compressors, agitators, mixers, etc.—provided the operating conditions are within these limits and provided a slight leakage rate is permissible.

The Sectaflex has a face-type mechanical seal in which the sealing action is obtained by arranging for intimate contact between the rubbing surfaces of two assemblies, one of which is held stationary while the other rotates with the shaft. As these components are subject to wear, they are each divided into two halves and assembled together in accurate alignment with the assistance of a solid locating ring. A third component, a flexible O-ring designed to prevent leakage along the shaft, is also split for ease of replacement.

A unique feature of the design is the means adopted for ensuring that the rubbing faces are accurately aligned at right angles to the shaft. This is effected by holding the stationary assembly firmly in a seal plate which is itself bolted to the stuffing-box casing. Set screws in the seal plate then enable the relative position of the stationary assembly to be varied within fine limits.

A variant of the basic design is also available in which provision is made for a positive circulation of the product being handled past the rubbing faces. This has the effect of: (a) removing frictional heat; (b) preventing the settling of sediments, abrasives or polymers; (c) keeping seals handling hot products cool; and (d) keeping seals handling cold products warm. **Flexibox Ltd., Nash Road, Trafford Park, Manchester, 17.**

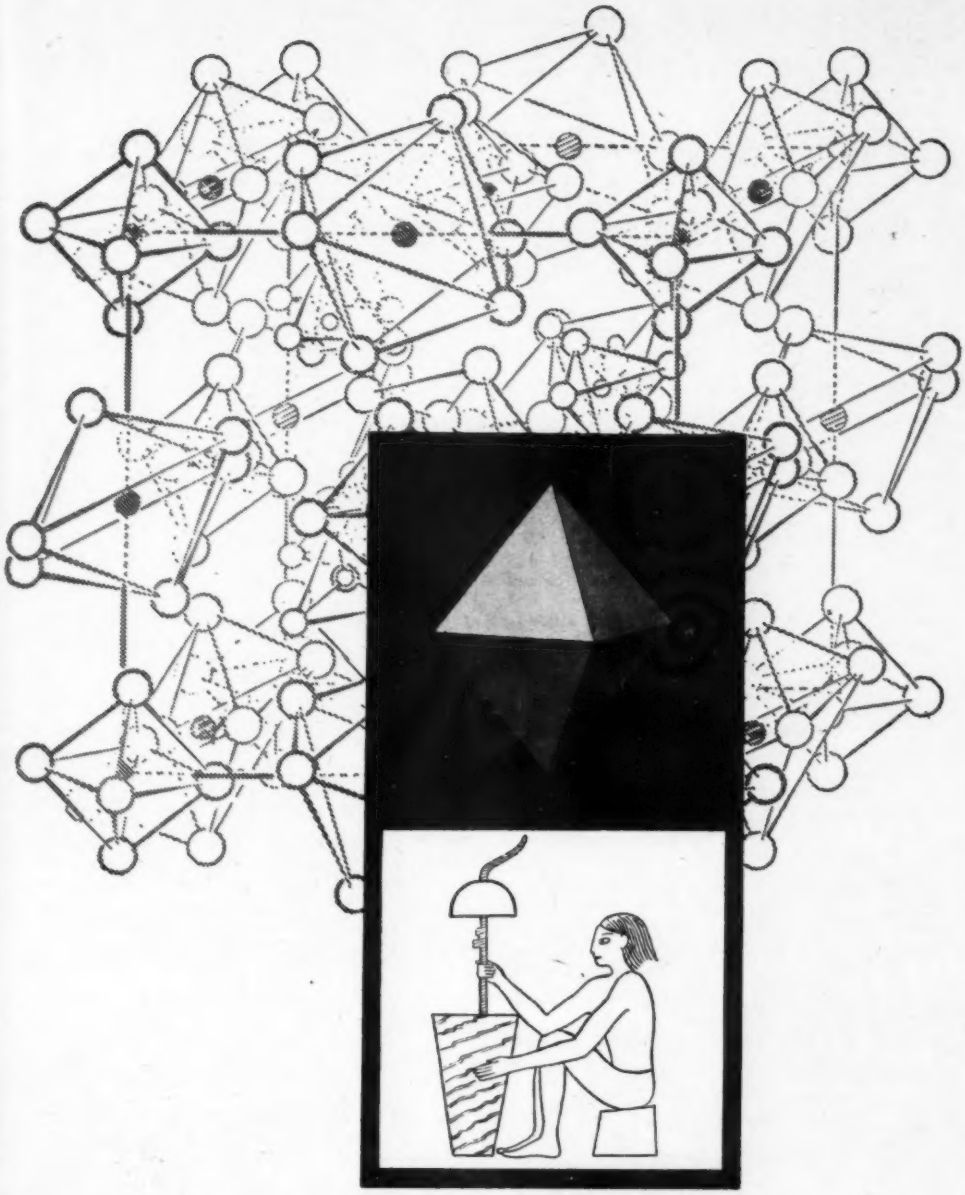
BCE 7495 for further information

Heating System

Protecting heat-transfer media against the formation of sludge and coke, the Merrill process system provides an accurately controlled heat source and imparts a constant velocity to the fluid. This heating system employs the Trent finned tube design with radial fins parallel to the heater axis in an attempt to provide maximum heat transfer without return bend obstruction. The size of the system depends on the number of heating elements installed. Each heating element is rated at 8 kW and has a design output of 25,000 Btu per hour. Maximum system size is 100,000 Btu per hour using four heating elements. The system can heat individual processes, or be used as a central system heating a number of processes at the same time, even at different temperatures.

Standard control for these systems is single stage, while multi-stage control is available in the 100,000-Btu and larger sizes. With multi-stage heating, all heaters are used when heat demands are high, as at starting, but a selected number are switched off when the set point is reached. Thus, full heat is available for fluctuating loads.

The system is suitable for three types of heat-transfer fluids: Parks-Cramer's H.T. Oil; Monsanto Chemical Co.'s "Aroclor 1248" or Dow Chemical Co.'s



The earliest chemical industry

Alum has been manufactured by Spence for over 100 years. It is one of the oldest chemicals used by mankind; indeed there are references which go back 4,000 years. In addition to being one of the largest manufacturers of alum and aluminium sulphate for paper making and water purification Spence are also producers of catalysts for petroleum refining and organic titanium compounds for the paint, plastic and textile industries.

SPENCE

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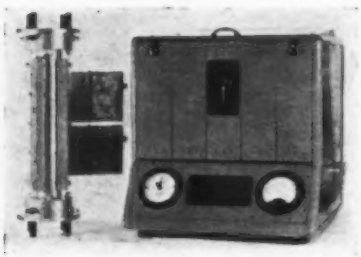
PLANT EQUIPMENT NEWS

"Dowtherm". It can be applied to existing equipment. All the piping equipment, with the exception of relief valves and pump, is insulated with at least 2 in. of 85% magnesia insulation or equivalent. The totally enclosed motor is fan cooled.

The system can be made explosion-proof with all controls furnished for Class 1, group D locations. In general, pressures even at 600°F are only slightly above atmospheric—just enough to overcome pipeline resistance plus static head of fluid in expansion tank, so heavy jacket walls or other reinforcements are not necessary. **Parks-Cramer Co., Fitchburgh, Mass., U.S.A.**

BCE 7496 for further information

Ultrasonic Flowmeter



The flowmeter developed by the British Scientific Instrument Research Association and shown at the recent Physical Society Exhibition depends for its operation upon the different rates at which sound will travel along a pipe in opposite directions, with the flow and against it. Two transducers are attached to the pipe forming the metering unit and these radiate into the fluid flowing through the pipe section. The time taken for two signals to travel between the transducers is measured as the phase difference between the two continuous signals. For absolute accuracy the flowmeter requires calibration, but linearity and reproducibility better than 1% can be achieved. It is a non-restrictive flowmeter especially suitable for the metering of slurries and corrosive fluids. The photograph shows a development model with the transducers mounted upon a section of 2-in. pipe. **British Scientific Instrument Research Association, South Hill, Chislehurst, Kent.**

BCE 7497 for further information

200-kV Portable X-ray Unit

The Andrex 200 X-ray unit weighs only 100 lb, is portable, provides a tube current of 5 mA, and has provision for water cooling, giving a 100% duty cycle. It is suitable for 1½-in. steel, to Class 1 standards, or 2¾-in. steel using fast calcium tungstate intensifying screens. The complete range now consists of a 130-kV automatic unit, a 140-kV unit, a 160-kV unit, a 160-kV-360° unit, a 200-kV unit and a 260-kV unit, giving a range of penetration from thin aluminium to over 3 in. of steel. All the units are of the robust, lightweight tank variety, with the transformers in the X-ray head and with no high-tension cables. Manufacturers are Holger Andreason of Copenhagen. British agents: **Watson & Sons (Electro-Medical) Ltd., East Lane, North Wembley, Middx.**

BCE 7498 for further information

Continuous Welded Helical Pipe

Suitable for gas, water or oil, continuously welded helical pipe, manufactured by the Jarrow Welding & Boiler Co. Ltd., in sizes ranging from 5 in. to 12 in. diameter, is now available in any specified lengths. These pipes fulfil the various requirements of all the British, American and European Standards bodies. In their manufacture strip steel is formed into a helix with the edges exactly aligned and a continuous weld (inside and outside, or outside only) completes the pipe.

In addition to advantages of strength and lightness, these helical pipes are said to offer savings in cost of up to 33% when compared with conventional spun cast pipes.

The machine at present in use to manufacture the pipes was designed and constructed by Mr. Wilfred Sanders, managing director of the Jarrow firm. It is said to be extremely simple and flexible and to produce pipes at a rate of about 3 ft a min. A second tube-making machine is now being assembled at the company's works and larger machines are envisaged. Inquiries for these pipes should be made to the sales agents, **Harwood & Co., East Boldon, Co. Durham.**

BCE 7499 for further information

Transistorised Quadrature Suppressor

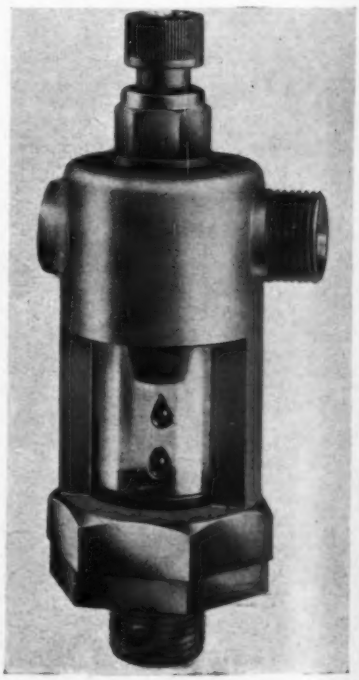
George Kent announce the introduction of the Type 1 Quadrature Suppressor for use with their range of electronic instruments when applied to the measurement of a.c. signals. The new unit effectively combats the quadrature effects that frequently occur in a.c. servo systems, such as those measuring the electrolytic conductivity or the rate of flow of liquids. These spurious signals can have very detrimental effects, for any quadrature components present in the input of an a.c. servo system cannot be reduced to zero by the main a.c. feedback, and give rise to an irreducible error signal. This in turn may cause an error in the output of the system or may cause partial or even complete saturation of the amplifier and resultant loss of sensitivity. The Kent Type 1 Quadrature Suppressor provides a completely satisfactory solution to the problem by applying an automatic cancelling action to any incoming quadrature components, whether stable in magnitude or not, while in no way interfering with the main input signal.

George Kent have also announced a new Type 3 Reference Unit, a completely new solid-state d.c. reference source, designed and developed for use with the company's range of electronic self-balancing recorders, indicators and controllers. A compact plug-in assembly operating directly from the normal a.c. mains supply, it provides an extremely stable, ripple-free output of 5.0 mA at 5 V for the slidewire of the instrument measuring circuit. Among the many advantages resulting from the use of the Type 3 Reference Unit are enhanced instrument performance; increased reliability; and fewer components (no standard cell, synchronous converter, etc.). **George Kent Ltd., Luton, Beds., England.**

BCE 7500 for further information

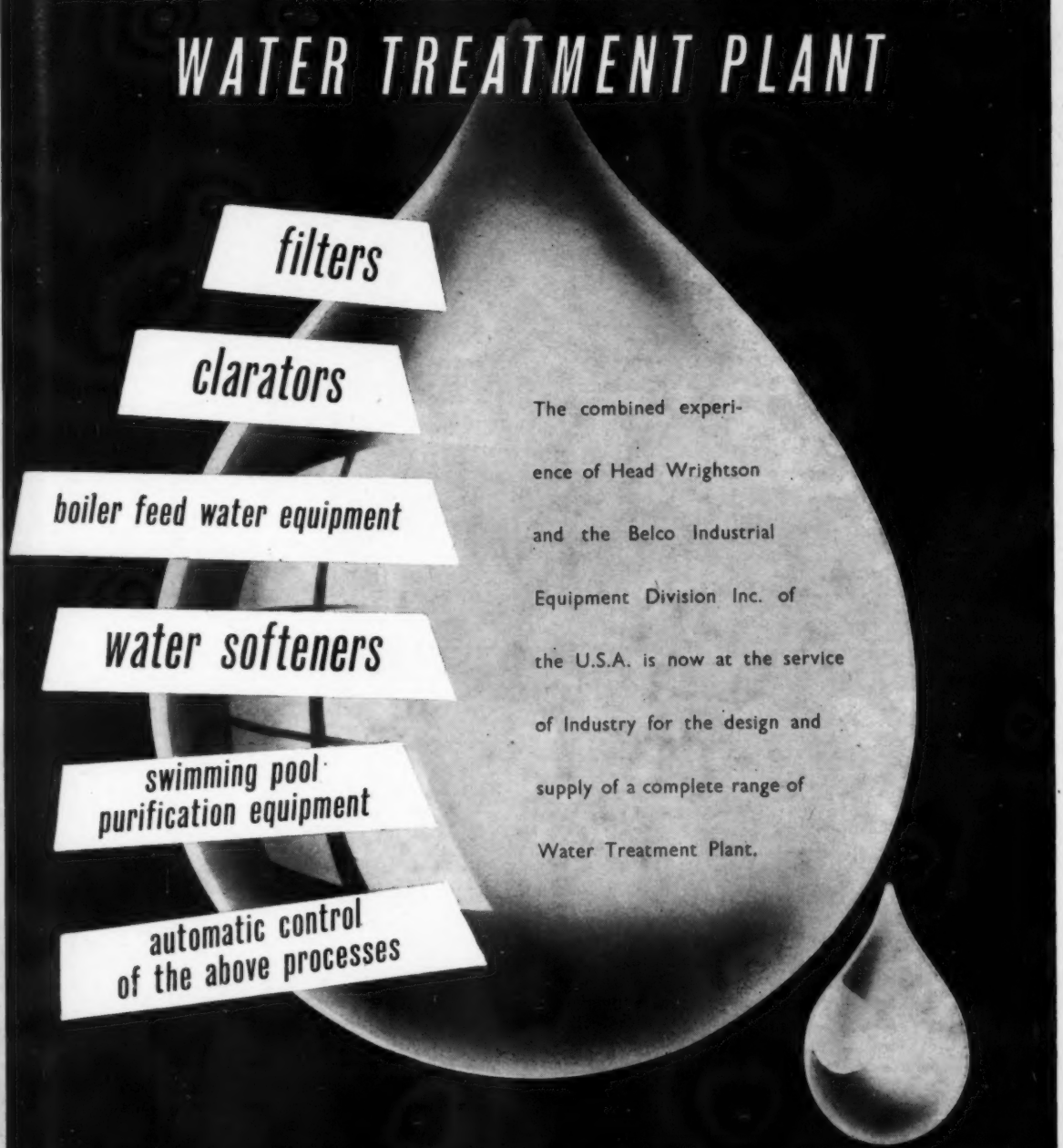
Adjustable Oil Feed Indicator

Only 4 in. high and 1¼ in. in diameter, a small and very compact oil feed indicator is nevertheless capable of giving a clear indication of oil flow. Feed can be adjusted by means of an Allen key controlling a fine thread control from 3 gpm to complete cut-off while the system is still running; the indicator will handle pressures up to 125 psi. Flow is observed through dirt- and damp-proof Perspex,



HEAD WRIGHTSON – BELCO

WATER TREATMENT PLANT



The combined experience of Head Wrightson and the Belco Industrial Equipment Division Inc. of the U.S.A. is now at the service of Industry for the design and supply of a complete range of Water Treatment Plant.

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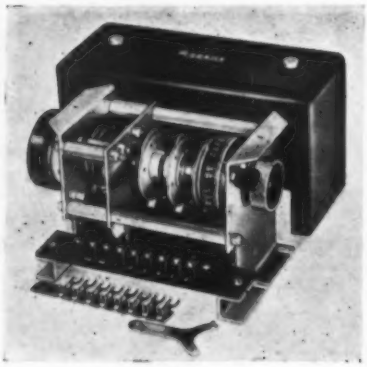
PLANT EQUIPMENT NEWS

sealed both ends. The inlet is a ¼-in. B.S.P. male connection and will fit either standard pipe or flexible hose. Outlet is a ¼-in. B.S.P.T. male. The body is constructed in bronze and the adjustable screw is made of hardened steel, cadmium plated. The Simmonds lock-nut is also cadmium plated and the unit is finished either dull nickel or black wrinkle. **Suba Hydraulics Ltd., Lind Road, Sutton, Surrey.**

BCE 7501 for further information

Multi-circuit Cam Timers

Improved versions of an existing range of timers were on show at the A.S.E.E. exhibition. Known as the "Varicams", their new features included: (a) special "quick-set" cams for setting accurately, quickly and permanently by a special tool supplied attached to each timer; (b) a drum dial calibrated every 2 degrees and a pointer allowing closer setting; (c) fully floating, well-fitted, oil-impregnated main bearings; and (d) terminals arranged for easy access, even when the timer is on a panel surrounded by other units.



In addition, there was a much smaller and simpler set of units with either "quick-set" or fixed cams, no setting dial and either "Amp", screw or solder connections. A further group consisted of larger, *de-luxe* versions of the "Varicam" with larger "quick-set" cams, two drum dials for each switch, special, individually removable switches, and air valves for direct operation of pneumatic cylinders which can be fitted in place of any of the switches. Sole distributors: **D. Robinson & Co., 717 London Road, Hounslow, Middx.**

BCE 7502 for further information

New Industrial Aerosols

A new way of applying colour coding paints to steel and other metal stocks with many obvious advantages is the aerosol spray.

DCMC are now marketing colour coding paints in a range of ten colours, packed in 16-oz aerosol containers. They are using a specially designed paint formulation with exceptional adhesion which can be applied to metals, wood and plastics under a wide range of difficult conditions.

The aerosol is economical, portable and compact and allows the operator to apply paint easily in spots, bands or stripes and eliminates the necessity for carrying a collection of brushes and paint pots (one for each colour) which require cleaning after use and which so often spill or evaporate. The aerosol method makes colour coding under A.I.D. and B.S.I. standards extremely simple, enabling the operator to use two or three colour codes easily. **DCMC, 2a Parkhurst Road, London, N.7.**

BCE 7503 for further information

Small Soniclean Equipment

Dawe have introduced to their range of ultrasonic cleaning equipment the type 1156 Soniclean Generator which operates at 40 kc/s and delivers 250 watts peak power into either the complete tank and transducer type 1160/T24 or into a stainless-steel immersible transducer type 1161/B18—both units capable of ultrasonically agitating 3 pt (1½ l) of cleaning solvent. These intense high-frequency sound waves produce tremendous effects in a cleaning solution. In a matter of seconds, oils, grease and oxides are literally blasted off the most complicated parts and assemblies. The inherent thoroughness and versatility of ultrasonic cleaning make it ideally suitable for automatic methods, eliminating dependence on manual labour and permitting completely automatic cleaning of many types of components and materials.

A technical leaflet (1156) and further details may be obtained from **Dawe Instruments Ltd., 99/101 Uxbridge Road, Ealing, London, W.5.**

BCE 7504 for further information

Readily Constructed Buildings

Romney-type buildings are easily erected, fire-proof, and can quickly provide covered space for factories, warehouses and similar buildings at moderate cost. Standard size is normally 96 ft × 35 ft wide, but they can also be supplied to any length in multiples of 8 ft. All sheeting supplied is new, whilst the framework and purlins are reconditioned. Main ribs are of 3 in. tubular steel, curved to a radius of 17 ft 6 in. Each complete rib is in four identical sections which bolt together through flanged ends. The purlins of 1½ in. × 1½ in. × ¼ in. steel angle are bolted to purlin cleats welded to main ribs. Covering them is 24-gauge galvanised corrugated steel sheeting. Sheets are 8 ft 6 in. long curved to 17 ft 9½ in. radius. Translucent fibreglass sheets 8 ft × 2 ft 8 in. can be supplied for deadlighting. The gables are of

steel frame construction of 4 in. × 2 in. channel posts and 1½ in. × 1½ in. × ¼ in. angle rails. **Recontainers Ltd., Green Lane, Hounslow, Middx.**

BCE 7505 for further information

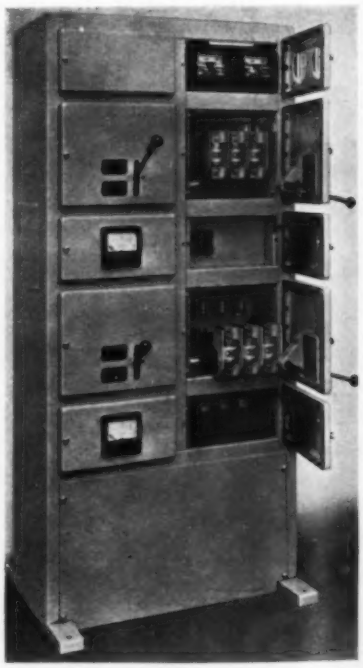
Oil-resistant Industrial Gloves

Based on Hycar nitrile rubber, new thin but strong gloves are said to be suitable for carrying out delicate work particularly in contact with solvents, such as the polyester hand lay-up process. They are also suitable for use by engineers as protection against machine oil and grease. The gloves are available in various sizes. The nitrile rubber is made by British Geon Ltd., a company in the Distillers Plastics Group. **Fireproof Tanks Ltd., The Airport, Portsmouth.**

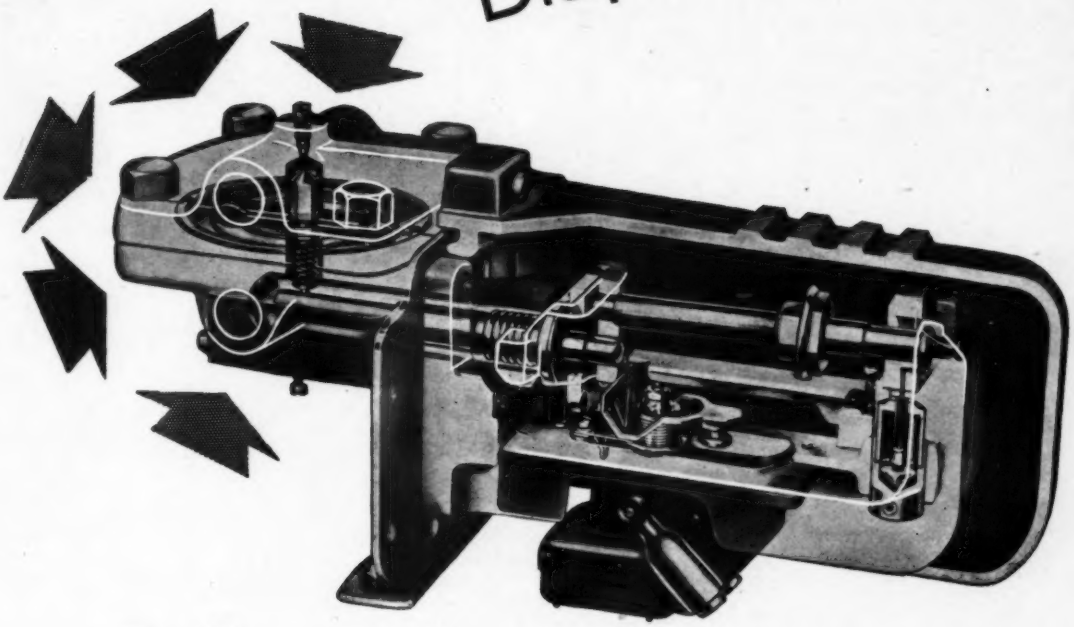
BCE 7506 for further information

Fuse Switchgear

Complying with British Standard 3185: 1959 and built in such a way as to ensure reliable service, a new set of heavy-duty fuse switchgear was shown for the first time at the Electrical Engineers Exhibition. Sizes range from 100 to 600 A current ratings and the gear may be



New Diaphragm



Drift-proof Flow Metering

In Honeywell's outstanding *pneumatic balance* differential converter, 'VITON' has now replaced Fluon as the standard diaphragm material. Neither time nor temperature has a significant effect on the characteristics of the new material—ensuring stable performance. The new 'VITON' diaphragm has a good chemical resistance. It can be used when metering a wide variety of fluids including dilute or concentrated alkalies and mineral acids, amines and hydrocarbons. Honeywell differential converters with Fluon coated diaphragms will remain available for applications involving other substances.

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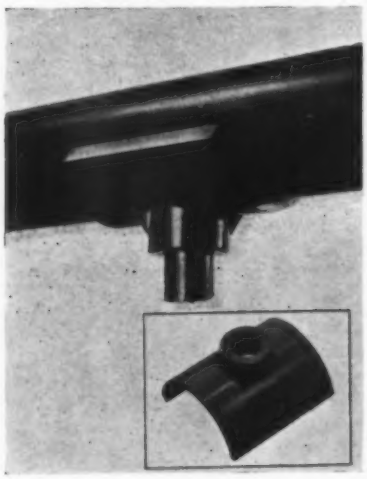
three-pole or three-pole and neutral link. Any make of H.R.C. fuse may be fitted, provided it complies with B.S.88: 1952, Form B. Switches up to the 300-A size are interchangeable, as are those from 400 to 600 A. The mechanism is common throughout the range and ensures quick make and quick break action. A switch will close fully on fault, regardless of the speed at which the handle is operated, and cannot blow open under fault conditions. All non-ferrous components are electro-tinned, except the contacts, which are silver plated. All ferrous components are treated with phosphate rust deterrent or are painted. The standard overall finish is medium hammer grey. **George Ellison Ltd., Perry Barr, Birmingham, 22B.**

BCE 7507 for further information

Thermoplastic Saddles

Durapipe & Fittings Ltd. have developed a range of thermoplastic saddles which enable branches to be cement welded to the existing pipelines without the necessity of breaking to insert tee pieces. A special tool also



enables the branch connection to be made while the pipe system is under pressure. The range consists of saddles for 3-, 4- and 6-in. pipe with offtakes in the case of the 6-in. pipe for 1½-, 1¼- and 1-in. branches and in the case of the 4-, and 3-in. pipe for 1¼- and 1-in. branches. The saddles can be used with rubber modified high impact P.V.C. and A.B.S. (styrene/butadiene acrylonitrile blend) pipe in sizes up to 6 in. and known as Durapipe V and Durapipe K respectively. Durapipe saddles are suitable for unplasticised P.V.C. pipes and have been test proved to be satisfactory for the full pressures recommended for the Durapipe thermoplastic pipes referred to. **Durapipe & Fittings Ltd., 56 Kingsway, London, W.C.2.**

BCE 7508 for further information

Transistorised Metal Detector

Metal Detection Ltd. announce the introduction of a transistorised metal detector, type T.L.D., for the detection of ferrous and non-ferrous metal inclusions. Advantages of the detector include the following: elimination of "warming-up" period required with valve circuits; smaller power and H.T. unit, giving a more compact and robust design; instantaneous in operation; and operationally safe. The T.L.D. detector is made in a range of sizes to suit belts from 6 in. up to 24 in. wide and aperture heights up to 8 in. The power supply (240 volts, 1 phase, 50 cycles) and relay stage are housed in a wall-mounting cabinet, whilst the oscillator and ancillary circuits are incorporated as part of the search coil assembly. **Metal Detection Ltd., 186 Moseley Street, Birmingham, 12.**

BCE 7509 for further information

New Publications

Markland Scowcroft Ltd have forwarded to us two leaflets describing the range of tanks manufactured by them for a variety of liquids. Copies of "Storage Tanks" and "Tanks for Liquid Storage" can be obtained from **Markland Scowcroft Ltd., Bromley Cross, Near Bolton.**

BCE 7510 for further information

Publication No. 598 describes the latest addition to the Visco range of air filters—the "K.M." oil-wetted type. In this, the filtration medium consists of galvanised wire mesh made from flattened wire and crimped to induce extreme air turbulence resulting in high efficiency. The filter cells are also light to handle and easy to clean. Copies from **The Visco Engineering Co. Ltd., Stafford Road, Croydon.**

BCE 7511 for further information

A new leaflet (C.V.S.) which describes a revised line of pipeline strainers, globe check valves and blanking-off caps recently introduced to the market is available from **Charles Winn & Co. Ltd., Granville Street, Birmingham, 1.**

BCE 7512 for further information

"Forging in Magnesium Alloys" is the title of an attractively produced booklet from High Duty Alloys Ltd. Including Technical Data on Magnuminimum and magnesium zirconium wrought alloys within its covers, this booklet should prove of interest to those responsible for the choice of alloy to meet particular requirements. **High Duty Alloys Ltd., 89 Buckingham Avenue, Trading Estate, Slough, Bucks.**

BCE 7513 for further information

Three new types of Rigidex high-density polyethylene have been added to the range of materials marketed by British Resin Products Ltd. They are copolymers of ethylene with other olefins and are designed for use in applications where better resistance to stress-cracking and superior load-bearing properties are required. Details of the copolymers are given in Technical Information Sheet No. 10, available on request from **Information Department, British Resin Products Ltd., Devonshire House, Piccadilly, London, W.1.**

BCE 7514 for further information

A new leaflet "P1/59", which lists and contains brief details of properties and applications of the various engineering plastics produced and stocked by Polypenco, can be obtained from **Polypenco Ltd., 68-70 Tewin Road, Welwyn Garden City, Herts, England.**

BCE 7515 for further information

The applications and performance of Venturi gas scrubbers comprise the subject-matter of an excellent brochure produced by Chemical Construction (G.B.) Ltd. In addition to presenting an illustrated description of the working principle of this type of scrubber, the brochure gives examples of its numerous applications which are illustrated by flow diagrams or by photographs of actual installations. Among the former is the cleaning of regenerator flue gas of a fluid-bed catalytic cracker, the aims being to arrest oil fumes, to recover the catalyst and to eliminate atmospheric pollution. **Chemical Construction (G.B.) Ltd., 9 Henrietta Place, London, W.1.**

BCE 7516 for further information

Shandon Scientific Co. Ltd. have forwarded to us a new leaflet describing their Jumo-Shandon adjustable contact thermometers for use in the temperature range −59°C to +625°C. **Shandon Scientific Co. Ltd., 6 Cromwell Place, London, S.W.7.**

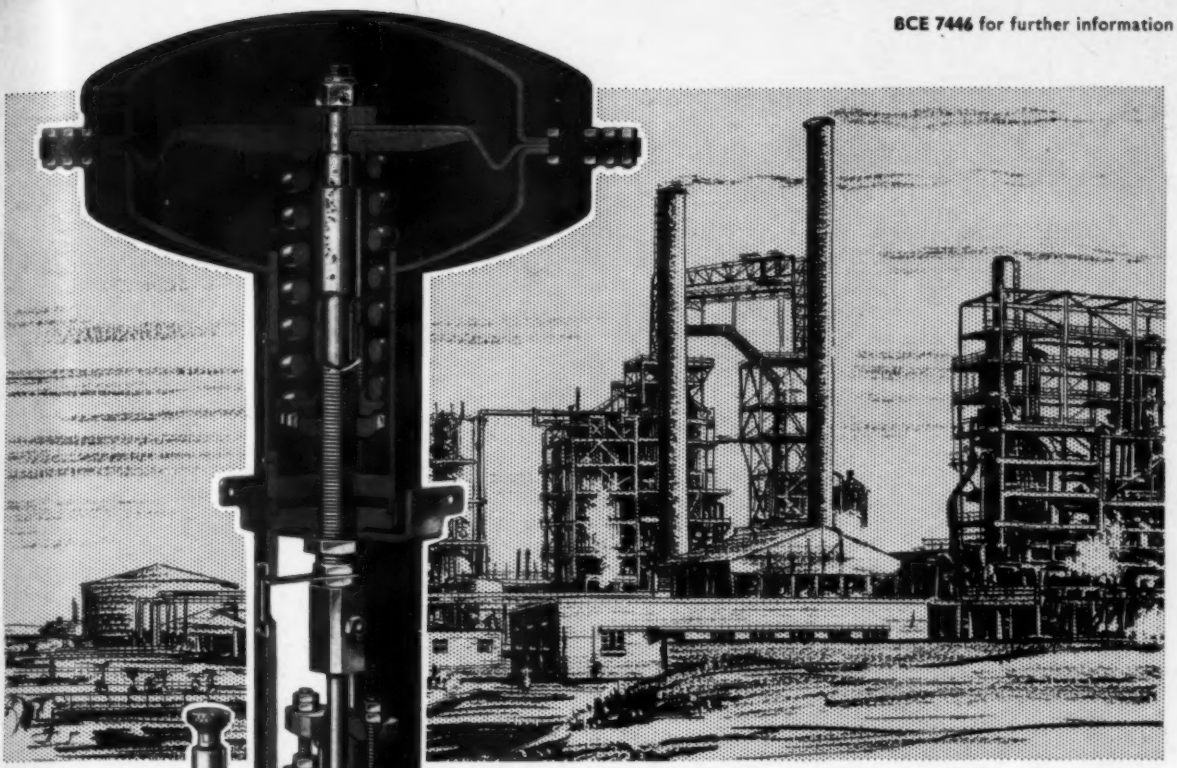
BCE 7517 for further information

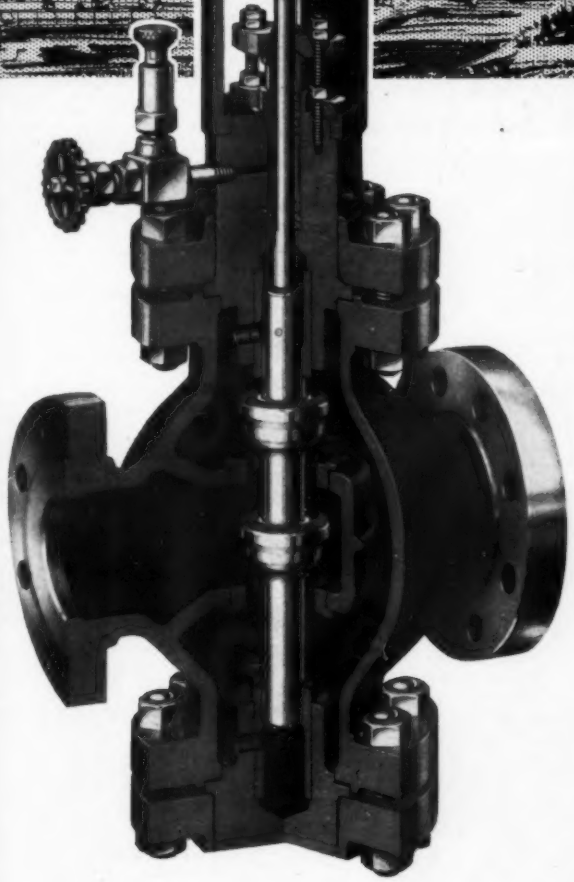
A leaflet describing Ether Ltd's new "Xactrol" potentiometer recording controllers, Series 2000, can be obtained from the company at either **Tyburn Road, Birmingham, 24,** or **Caxton Way, Stevenage, Herts.**

BCE 7518 for further information

Midland Silicones Ltd. have published a technical booklet describing the engineering applications of their range of silicone fluids. The booklet, well illustrated, is entitled "Engineering Guide to MS Silicone Fluids" (Ref. No. G.11), and emphasises that silicone fluids are outstanding for their exceptional thermal stability and resistance to oxidation. All these fluids show a remarkably small change in viscosity with temperature and resist breakdown due to shear. They are water-repellent and retain good dielectric characteristics over a wide range of temperatures and frequencies. Amongst the other desirable properties the silicone fluids exhibit are included low volatility, low freezing point, high flash point and incompatibility with organic oils and polymers. The booklet has many charts and tables. **Midland Silicones Ltd., 68 Knightsbridge, London, S.W.1.**

BCE 7519 for further information





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World of Chemical Engineering

U.K.'s First Synthetic Phenol Plant

The first synthetic phenol plant of its type in the United Kingdom, built at a cost of £4 million for British Hydrocarbon Chemicals, a joint subsidiary of British Petroleum and Distillers, is now on stream at Grangemouth. The plant consists of two units. The first produces cumene by reacting benzene with propylene; the second derives phenol and acetone from the cumene by a process invented and developed by Distillers. Production capacity is 13,000 tons of phenol a year, but the two units are so designed that there is a surplus of cumene. B.H.C. state that they are already exporting cumene by regular bulk shipments from Grangemouth to Europe. Licences for the use of the synthetic phenol process have been awarded to manufacturers in other countries and plants using it have been completed, or are being built, in Belgium, Canada, France, Germany, Italy, Japan and the U.S. World output of phenol by this process by the end of 1961 is expected to reach a level of 200,000 tons a year.

Shell Plant for Synthetic Rubber

Shell Chemical have announced plans for the construction of a plant at Carrington for the manufacture of new types of synthetic rubber. Details of the two types given are polybutadiene (a type not made on a commercial scale at present) and polyisoprene (made only on a commercial scale by the chemical division of Shell Oil in the U.S.). The plant will take two to three years to complete and will probably cost some several million pounds, and it will be capable of switching from producing mainly polybutadiene to producing polyisoprene as the market dictates. Limited supplies of both will shortly be made available to the trade for evaluation. A similar plant is also to be built in Holland by Shell Nederland.

Henry Wiggin on Tour

In London during March Henry Wiggin & Co. Ltd. held the second of their private exhibitions on the use of Wiggin Nickel Alloys in Industry. At this occasion Mr. R. E. Ansell, director and sales manager, informed the Technical Press that his company had plans to tour the Continent for the first time with the exhibition, Milan being the first European city to be visited (May 10 to 21). The aim of the exhibition (which includes film shows and a series of lectures) is to assist engineers and designers to make the best use of the company's specialised high-nickel alloys. Mr. Ansell, besides announcing that his company will shortly introduce a new heat-resisting alloy to their existing range, also gave details of a £25 million development programme being undertaken at his company's Hereford plant. When completed in 1965, the extensions to the plant will enable the concentration of all the company's activities which are at present carried out in three other plants. Eventually the Hereford plant will employ 3500 people.

Monsanto to make Silicon

Silicon, stated as of the highest quality commercially available anywhere in the world, is to be made in Great Britain by Monsanto Chemicals. This development, the company announces, is the result of an agreement with the Siemens-Companies of West Germany, originators of the manufacturing process which Monsanto is to operate at its Ruabon, North Wales, factory. Production will begin in late 1960. The Monsanto plant will produce float-zoned single crystals of high P-type resistivity or doped float-zoned single crystals of P- or N-type resistivity. Float zoning, floating zone or molten zone refining is a process of refining in which molten zone produced by H.F. induction heating is made to traverse a solid rod or bar of impure material, progressively purifying the material. Monsanto will also supply polycrystalline rod for further processing, doping and crystal forming by customers.

News Briefs

British Geon Ltd. (jointly owned by Distillers and B. F. Goodrich Chemical of America) announces that work will shortly begin on a £2-million extension to their polyvinyl chloride plant at Barry, South Wales. This will be the eighth extension of the Geon P.V.C. plant during the 13 years it has been in operation. Constructional work is expected to be completed during the second half of next year.

The Gas Council has decided to establish a development and planning section to be responsible for the design and development to full-scale size of new production processes including those discovered at the research stations of the Council. The new proposal will also ensure continuous contact between those responsible for research in the industry and those responsible for commercial production, a contact necessary for the effective development of any new processes.

Witco Chemical Co. is to build a plant in the Midlands to produce synthetic rubber latices. With headquarters in London, Witco Chemical has sales offices in London, Manchester, Glasgow and Rotterdam, and a marketing company in France. It also has a plant and laboratories at Droitwich. The company is the British subsidiary of the Witco Chemical Co. Inc. of the U.S.

G. & J. Weir Ltd. have acquired the exclusive world rights for the manufacture and sale of the Davidson liquid extraction and filter press (see *British Chemical Engineering*, 1960, **5**, 2, 130). The services of the inventor, Mr. M. W. Davidson, have been retained.

Chemical Works Projects Ltd. has been formed by P. G. Engineering Ltd., Humphreys & Glasgow Ltd and Simon-Carves Ltd. to supplement their normal activities by undertaking contracts for large fertiliser and chemical projects overseas. The joint company thereby will be able to call on extensive resources. The board will consist of Mr. J. P. V. Woolam, Mr. G. Gresle Farthing and Mr. R. W. Rutherford, who will be the first chairman, each having an alternate director. The registered office of the company will be Simon House, 28/29 Dover Street, London, W.1.

Hygrotherm Engineering Ltd., 115 Princess Street, Manchester, are to design and supply Hygrotherm vapour phase heating systems to I.C.I. One is for the I.C.I. polyurethanes plant to be installed near Fleetwood, Lancashire, and the other for a solvents plant which I.C.I. are to operate near Runcorn, Cheshire. In both cases the installations will employ the new I.C.I. diphenyl oxide/diphenyl heat-transfer medium known as "Thermex".

Corrosion Technical Services Ltd., Sunleys Island, Great West Road, Brentford, Middx., in association with Soil Mechanics Ltd., has acquired the fixed assets and trade-mark of Corrosion Proof Products Ltd. The technical staff of Corrosion Proof Products Ltd. have also joined the company.

Firth Cleveland Pumps Ltd., a member of the Firth Cleveland Group, have moved to a 40,000 sq. ft factory at Earl Shilton (Tel.: Earl Shilton 2071), about two miles from Markfield, Leicester, where the company has been established for many years.

Simon-Carves Ltd. are to design and supply equipment for a polythene plant for Petroleos Mexicanos, the national oil company of Mexico. The plant is to be installed on a site near Mexico City. It will operate the I.C.I. process, an appropriate agreement having been concluded between I.C.I. and Petroleos Mexicanos.

Overseas News

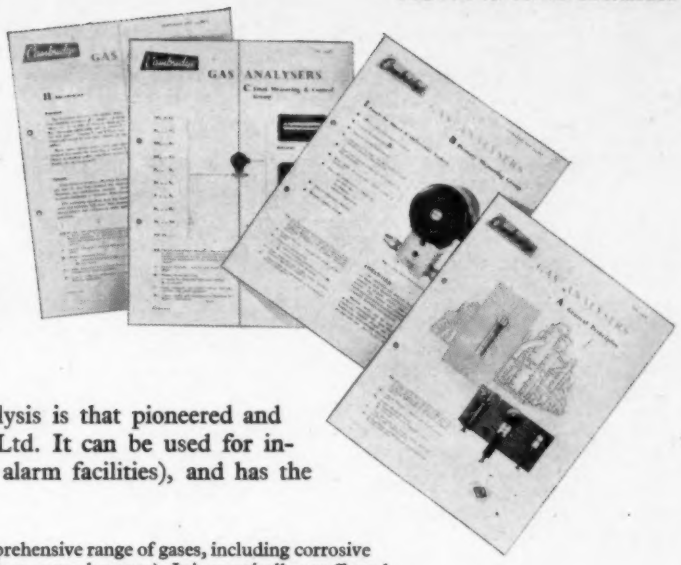
A joint company is to be formed in Denmark for the manufacture of polyolefins. Initially, "Alkathene", the brand of polythene developed by I.C.I. Ltd., will be made, using their high-pressure process. Partners in this new enterprise are I.C.I. and A/S Dampskibsselskabet Svendborg and Dampskibsselskabet af 1912 A/S, owners of the Maersk Refinery, Copenhagen.

BCE 7447 for further information

Cambridge

GAS ANALYSERS

for Industry and Research



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It can be used to analyse a very comprehensive range of gases, including corrosive (HCl, Cl_2, SO_2) or inert (argon, helium, neon, krypton). It is practically unaffected by the rate of flow, pressure, or temperature of the gases, and will also measure static gases. The equipment is accurate, but robust. The method is electrical, simple, flexible and reliable. It is direct-reading (or recording), and the analysis is continuous. It is easy to install, and the indicator (and/or recorder) may be any reasonable distance from the measuring unit. Intrinsically safe circuits are available for dangerous working conditions.

Send for the publications illustrated above (AR144). For future publications (another section of List 144 is still to be published) send for Mailing Form AR/3/60.

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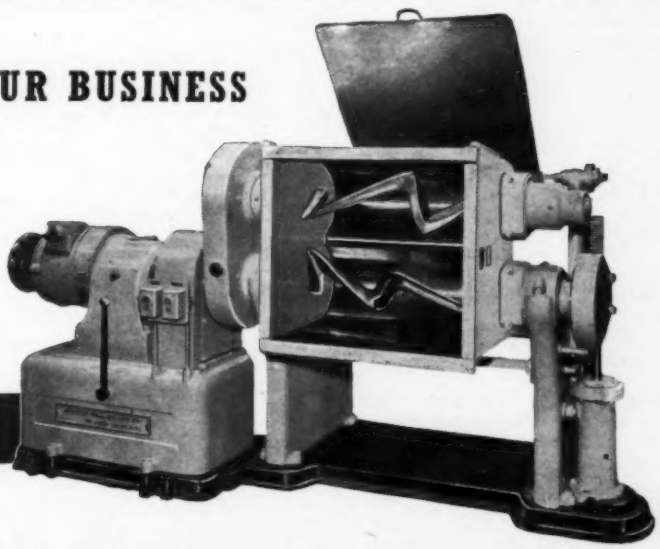

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BCE 7448 for further information

British Titan Products of Canada, a subsidiary of British Titan Products Co. of Great Britain is to establish a $15 million plant at Tracy, just outside the city limits of Sorel, Quebec. Plans for the plant are nearly completed, and construction is scheduled to start this year.

What is claimed as the largest single sulphuric acid producing unit in the world is now on stream. It is owned by Dixon Chemical Industries and located at Paulsboro, New Jersey, U.S.A. This plant, costing over $5 million, was designed and built by the Chemical Construction Corp., using the Chemico process. The unit has a production capacity of 715 tons/day of 98% acid, processing acid sludge obtained from oil refineries located between the Delaware Valley and Southern New England. The plant has extreme flexibility through the range of 120% to 25% of design capacity. Additionally, acid feedstock varies widely; i.e., analyses range from 90% acid, 4% water and 6% hydrocarbons to only 75% acid, 4% water and 21% hydrocarbons. Overall acid recovery from the sludge averages 95%.

Australia's most up-to-date gasworks are to be built at Geelong, near Melbourne, by Humphreys & Glasgow Ltd. The works, due to go into operation in 1961, will consist of two Onia-Gegi catalytic reforming units, each producing 1,500,000 cu. ft of town gas a day. The units will use tail gases piped from a Shell oil refinery five miles away. As an alternative feedstock, liquefied petroleum gas, for which storage facilities are being installed, will ensure continuous output when the refinery is shut down for maintenance.

The sulphuric acid plant (designed, engineered and constructed by Simon-Carves Ltd., a member company of the ISCON consortium at Durgapur), which forms part of the coke oven by-product plant at Durgapur Steel Project (see page 154, February, 1960, issue), went into production recently. The plant is capable of producing 60 tons of sulphuric acid a day, and has already reached its rated capacity since it was commissioned. The sulphuric acid produced will be used primarily for the production of sulphate of ammonia.

Du Pont had, during 1959, approximately 2300 technically trained people engaged in research and development on new processes for established products, on new products and in fundamental research. The cost of this work was $90 million, the same as in 1958. About $14.5 million was spent on fundamental research in organic, inorganic and physical chemistry, physics, microbiology, biochemistry and engineering. This work is conducted in fields of present or potential interest to the company without regard to near-term commercial objectives. About 400 scientists of widely diverse training are now engaged in fundamental research.

A new library is to be established in Canberra which will bring together the documents telling the history of science in Australia. A gift of £A25,000 to the Academy of Science by a Sydney philanthropist, Mr. Adolph Basser, has made this possible. The President of the Academy, Sir John Eccles, said that the Basser Library at the Academy would become a centre for research into scientific history as well as a storehouse of scientific documents and those of a more personal character, in which future biographers would find source material. Australia's present scientists would be asked to hand over their documents to the library or to bequeath them when they die.

Contracts

William Boby & Co. Ltd. have been awarded contracts valued at £16,000 for dealkalisation/base exchange plants by George Wimpey & Co. Ltd. for the Union Carbide Ltd. works at Hythe, Hants.

The British General Electric Co. (Pty.) Ltd., Johannesburg, representatives of The General Electric Co. Ltd., England, has received contracts for two coal preparation plants worth approximately £230,000 to the company. The first plant will be situated at the Landau Colliery of the South African Coal Estates (Witbank) Ltd. and will clean 6 in. × ¼ in. raw coal at the rate of 350 short tons per hour. The second, for Natal Navigation Collieries & Estate Co. Ltd., will be built at their Kilbarchan Colliery and will handle 6 in. × ¼ in. coal at the rate of 320 short tons per hour.

Daniel Adamson & Co., of Dukinfield, Cheshire, have been awarded the order for 13 air coolers and condensers for the new Turkish oil refinery at Mersin (see p. 228, March issue).

Simon-Carves Ltd. have received from the East India Distilleries & Sugar Factories Ltd. a contract to build a complete new factory to make approximately 51,000 tons a year of compound fertilisers based on ammonium phosphate. The total cost is expected to be in the region of £3 million. In addition to the compound fertiliser plant, the factory will include plants for the production of synthetic ammonia, sulphuric acid and phosphoric acid, together with equipment for handling incoming raw materials and outgoing finished products. The factory is to be built at Ennore, near Madras, and is scheduled to come into production in 1962.

P. G. Enginering Ltd. have received contracts for process plant from Canada and India of a total value exceeding £1¼ million. The Canadian plant is for Brockville Chemicals Ltd. and will be for the complete design, construction and commissioning of a hydrogen plant at a new works now in course of erection near Maitland, Ontario. The plant will produce 15 million cu. ft of hydrogen daily, mainly for ammonia synthesis, using as a feedstock natural gas delivered by pipeline from Western Canada. This plant is scheduled for completion early in 1961.

The Indian order is for Fertilisers & Chemicals, Travancore Ltd., South India, and calls for the construction of a Texaco partial-oxidation gasification plant to produce carbon monoxide and hydrogen, followed by high-pressure CO conversion, removal of CO_2 and residual H_2S by water scrubbing. Initially, the plant will process naphtha, but will be laid out so that if fuel oil is to be used the additional acid gas purification plant can be added. One of the interesting features of this plant is that carbon produced in the Texaco generator is recovered and recycled.

Head Wrightson Iron and Steel Works Engineering Ltd., of Thornaby-on-Tees, announce the receipt of an order from the Skinningrove Iron Co. Ltd. for the design and construction of a materials handling and iron ore sintering plant at their works at Carlin How, North Yorks. The plant is designed to produce ultimately 7000 tons a week of self-fluxing blast-furnace sinter from a mixture of imported and home ore fines. The total value of the work involved is approaching £700,000. The present order follows the contract recently placed with Head Wrightson for a similar but somewhat larger plant at the Clyde Iron Works of Colvilles Ltd.

Chemical Construction (G.B.) Ltd. have recently been awarded two major contracts by the newly-formed Albatros Sulphuric Acid and Chemical Works at Vlaardingen, Holland. This new company is jointly owned by Albatros Superfosfaatfabrieken N.V. of Utrecht, member of the Royal Dutch Salt Group, and Cyprus Mines Corp. of Los Angeles. The projects involve a very large complex sulphuric acid contact plant of a capacity of more than 100,000 MT/year, designed to take SO_2 gas from pyrites and from a unique plant of Chemico design which is to decompose 56% sulphuric acid refinery sludge coming from the adjacent Shell refinery. Total value of the two Chemico plants, completely installed, will be approximately £650,000.

People in the News

Field-Marshal Sir William Slim has been appointed as an additional director of I.C.I. Ltd. with effect from March 10, 1960. He will act as a non-executive director. A further appointment announced is that of **Mr. C. I. Rutherford**, who has been appointed production director of I.C.I. Fibres Division with effect from April 1, 1960. He succeeds **Mr. W. F. Osborne**, who is retiring after 34 years' service with the company and its predecessors.

Mr. D. R. Hunt has been appointed general manager of Alto Instruments (Great Britain) Ltd. Mr. Hunt, formerly commercial manager of Power Auxiliaries, Swindon, took up his appointment on March 1.

Mr. B. Heath, managing director of Powell Duffryn Carbon Products Ltd. and a director of other companies in the Powell Duffryn Group, relinquished his Powell Duffryn appointments on February 29, 1960, to take up another appointment. Following Mr. Heath's resignation, **Mr. R. Turner**, acting managing director of Powell Duffryn Technical Services, has joined the board of Powell Duffryn Carbon Products as deputy chairman, and **Mr. F. W. Stokes**, a director and the present works manager of the company's factory at Hayes, has been appointed general manager.